MOTOROLA INC.
Communications
Sector

INTRAC 2000®
Modular Remote Terminal Unit
MRTU Plus

CONTENTS of BINDER

DIVIDER 1

Name of Instruction Manual	Catalog Number
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6. Supplement to MaxTrac UHF 403-420 MHz FUE1842AA	68P02975G51
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DIVIDER

Name of Instruction Manual	Catalog Number
1. External Radio Interface (XRI)	68P02938G56
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6. Microwave Radio Interface	68P02963G50
7. -48 V Power Supply	68P02952G41

In all of the instruction manuals under DIVIDERS 2 and 3, the Decoder and Encoder Boards should be referred to as "Basic Module Main Board," which is described in MRTU General Instructions Manual 68P02962G20 and MRTU Service Instructions Manual 68P02957G60 (DIVIDER 1).

MOTOROLA

INTRAC 2000®

Modular Remote Terminal Unit
General Installation Instructions

Instruction Manual

68P02962G20-O

COMMERCIAL WARRANTY
(STANDARD)

Motorola radio communications products are warranted to be free from defects in material and workmanship for a period of ONE (1) YEAR, (except for crystals and channel elements which are warranted for a period of ten (10) years) from the date of shipment. Parts, including crystals and channel elements, will be replaced free of charge for the full warranty period but the labor to replace defective parts will only be provided for One Hundred-Twenty (120) days from the date of shipment. Thereafter purchaser must pay for the labor involved in repairing the product or replacing the parts at the prevailing rates together with any transportation charges to or from the place where warranty service is provided. This express warranty is extended by Motorola Communications and Electronics, Inc., 1301 E. Algonquin Road, Schaumburg, Illinois 60196, to the original purchaser only, and only to those purchasing for purpose of leasing or solely for commercial, industrial, or governmental use.

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This warranty is void if:

a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage;
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

This warranty extends only to individual products, batteries are excluded, but carry their own separate limited warranty. Because each radio system is unique, Motorola disclaims liability for range, coverage, or operation of the system as a whole under this warranty except by a separate written agreement signed by an officer of Motorola.

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In order to obtain performance of this warranty, purchaser must contact its Motorola salesperson or Motorola at the address first above shown, attention Quality Assurance Department.

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MOTOROLA INC.
Communications
Sector

INTRAC 2000®

Modular Remote Terminal Unit
General Installation Instructions

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FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar types of equipment. It contains all service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date are incorporated by Instruction Manual Revisions (SMR). These SMR's are added to the manuals as the engineering changes are incorporated into the equipment.

2. MODEL AND KIT IDENTIFICATION

Motorola equipments are specifically identified by an overall model number on the nameplate. In most cases, assemblies and kits which make up the equipment also have kit model numbers stamped on them. When a production or engineering change is incorporated, the applicable schematic diagrams are updated.

3. SERVICE

Motorola's National Service Organization offers one of the finest nation-wide installation and maintenance programs available to communication equipment users. This organization includes approximately 900 authorized Motorola Service Stations (MSS) located throughout the United States, each manned by one or more trained, FCC licensed technicians.

These MSS's are independently owned and operated and were selected by Motorola to service its customers. Motorola maintenance is available on either a time and material basis or on a periodic fixed-fee type arrangement.

The administrative staff of this organization consists of national, area and district service managers and district representatives, all of whom are Motorola employees with the objective to improve the service to our customers.

Should you wish to purchase a service contract for your Motorola equipment, contact your Motorola Service Representative, or write to:

National Service Manager
Motorola Communications and Electronics, Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

REPLACEMENT PARTS ORDERING

ORDERING INFORMATION

When ordering replacement parts or equipment information, the complete identification number should be included. This applies to all components, kits, and chassis. If the component part number is not known, the order should include the number of the chassis or kit of which it is a part, and sufficient description of the desired component to identify it.

Crystal and channel element orders should specify the crystal or channel element type number, crystal and carrier frequency, and the model number in which the part is used.

Orders for active filters, Vibrasender and Vibrasponder resonant reeds should specify type number and frequency, should identify the owner/operator of the communications system in which these items are to be used; and should include any serial numbers stamped on the components being replaced.

MAIL ORDERS

Send written orders to the following addresses:

Replacement Parts/Test Equipment/
Crystal Service Items:
Motorola, Inc.
Communications Parts Division
Attention: Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

Federal Government Orders:

Motorola Inc.
Communications Parts Division
Attention: Order Processing
1701 McCormick Drive
Landover, MD 20785

International Orders:

Motorola Inc.
Communications Parts Division
Attention: International Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

TELEPHONE ORDERS

Replacement Parts/Test Equipment:

Call: 1-800-422-4210
1-800-826-1913 (For Federal Government Orders)

Crystal Service Items:

Call: 1-800-323-1570
1-800-445-4564 (For Illinois Residents)

TELEX/FAX ORDERS

Replacement Parts/Test Equipment/
Crystal Service Items:

Telex: 280127
FAX: 312-576-6285

Federal Government Orders:

FAX: 301-925-2473 or 301-925-2474

CUSTOMER SERVICE

Replacement Parts/Test Equipment:

Call: 1-800-537-7007

Crystals:

Call: 1-800-323-0234

Parts Identification:

Call: 312-576-7418

NATIONAL DATA SERVICES

1711 West 17th Street, Tempe, AZ 85281

Call: 602-994-6472, TWX: 910-951-1334

MODEL CHART

		F6023B	F6053B	F6014B	F6509A	F6523A	F6553A	F6514A	F6574A	F6556A	F6573B	F6709A	F6723A	F6753A	F6714A	F6774A	F6756A	F6773B	F6799A
CKN6070A	CABLE, ANTENNA								X							X			
FHN5509A	COVER, BATTERY REPLACEMENT					X	X	X					X	X	X				
FHN5530B	HOUSING, LARGE											X	X	X	X	X	X	X	
FHN5538A	FRAME (19" RACK)																		X
FHN7819B	HOUSING, SMALL				X	X	X	X	X	X	X								
FKN5601A	CABLE, ANTENNA, BNC TO N TYPE FEMALE	X	X	X		X	X	X					X	X	X				
FKN5727B	POWER CABLE, DARCOM TO I/F BOARD									X							X		
FKN5771A	FLAT CABLE, DARCOM TO I/F BOARD										X							X	
FKN5798A	CABLE, ANTENNA MINI UHF TO N TYPE FEMALE										X							X	
FKN5804A	CABLE, COM TO RADIO INTERFACE BOARD				X				X	X	X	X				X	X	X	
FKN5810A	CABLE, RADIO								X							X			
FKN7971A	POWER CABLE DARCOM									X							X		
FKN7995A	CABLE,ANTENNA PHONO MALE TO N TYPE FEMALE									X							X		
FLD1684A	RADIO, 2W, 136-150.8 MHZ	O				O							O						
FLD1685A	RADIO, 2W, 150.8-162 MHZ	O				O							O						
FLD1686A	RADIO, 2W, 162-174 MHZ	O				O							O						
FLD1687A	RADIO, 5W, 136-150.8 MHZ		O				O							O					
FLD1688A	RADIO, 5W, 150.8-162 MHZ		O				O							O					
FLD1689A	RADIO, 5W, 162-174 MHZ		O				O							O					
FLE1613A	RADIO, 1W, 403-430 MHZ			O				O							O				
FLE1614A	RADIO, 1W, 440-470 MHZ			O				O							O				
FLN1477A	MICROWAVE RADIO INTERFACE (MRI)																		X
FLN4489A	LABEL, AMRTU																		X
FLN4500C	TOOLING KIT																		X
FLN4562A	HARDWARE, CHASSIS MOUNTING																		X
FLN4563A	MOUNTING MODULE FOR 19" RACK																		X
FLN4604B	HARDWARE, BASE				X	X	X	X	X	X	X	X	X	X	X	X	X	X	
FLN4611A	MOUNTING, RADIO								X							X			
FLN4627B	PANEL, STATUS DISPLAY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FLN4631A	MOUNTING, RADIO FOR MAXAR									X							X		
FLN4634A	SWITCH, TAMPER					X	X	X					X	X	X				
FLN4649A	MAIN BOARD	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FLN4659A	LABEL, MAIN BOARD	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

X = One item supplied.
O = One item supplied dependent upon frequency.

Sheet 1 of 2

MODEL CHART CONTINUED

	F6023B	F6053B	F6014B	F6509A	F6523A	F6553A	F6514A	F6574A	F6556A	F6573B	F6709A	F6723A	F6753A	F6714A	F6774A	F6756A	F6773B	F6799A
FLN4666A BATTERY, 5 AH				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FLN4792A MODULAR HOUSING				X				X	X	X	X				X	X	X	X
FLN5012A HDW FOR MTG & INTFC BD				X				X	X	X	X				X	X	X	O
FLN4847A CHARGER & SWITCHES, COMMUNICATION	X	X	X															X
FLN5013A CHASSIS, LARGE BASE											X	X	X	X	X	X	X	
FLN5008A CHASSIS, SMALL BASE				X	X	X	X	X	X	X								
FLN4919A HARDWARE FOR 5 AH BATTERY				X	X	X	X	X	X	X	X	X	X	X	X	X	X	
FLN4925A MODULAR HOUSING, RADIO & DISPLAY	X	X	X	X	O	X	X					X	X	X				
FLN4940A OUTDOOR CHASSIS FOR HOUSING				X				X	X	X	X				X	X	X	
FLN4948A RADIO INTERFACE BOARD				X				X	X	X	X				X	X	X	
FLN4977A TAMPER SWITCH FOR MOUNTING				X				X	X	X	X				X	X	X	
FLN4954A MOUNTING, PANEL	X	X	X															
FLN4999A LABEL (for all models)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O
FLN5720A HARDWARE, MAIN BOARD	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
FLN5801A LABEL, VHF 2W	X																	
FLN5802A LABEL, VHF 5W		X																
FLN5879B TRANSFORMER, 115V	X	X	X															
FPN1608B POWER SUPPLY				X	X	X	X	X	X	X	X	X	X	X	X	X	X	
FRN5045A HARDWARE, ANTENNA ADAPTOR									X								O	
FUD1841AA RADIO,20W,136-162 MHZ (see for V349aa)										O							O	
FUD1841AB RADIO, 20W, 146-174 MHZ										O							O	
FUE1611AB RF XCVR, 15W, 450-470 MHZ								O							O			
FUE1613AB RF XCVR, 15W, 403-420 MHZ								O							O			
FUF1535AA RADIO, 5W, 928-960 MHZ, HALF-DUPLEX									O							O		
FUF1535AC RADIO,5W,928.8625-928.9875 MHZ,PTP,HD									O							O		
FXN1601A CRYSTAL, RECEIVER, DARCOM								X							X			
KXN1003B CHANNEL ELEMENT, TRANSMITTER DFM 2PPM								X							X			
KXN6206AA CRYSTAL, TRANSMITTER, VHF	X	X			X	X						X	X					
KXN6206AB CRYSTAL, TRANSMITTER, UHF			X				X							X				
KXN6207AA CRYSTAL, RECEIVER, VHF	X	X			X	X						X	X					
KXN6207AB CRYSTAL, RECEIVER, UHF			X				X							X				
NLN7401A BATTERY, 450 mAH	X	X	X															
NXN6116A CRYSTAL, 2nd OSCILLATOR, HIGH SIDE	X	X			X	X						X	X					
NXN6118A CRYSTAL, 2nd OSCILLATOR, HIGH SIDE			X				X							X				

X = One item supplied.
O = One item supplied dependent upon frequency.

OPTIONS

V026AD Slave Operation (for F67XX models with HT440 radio)

FHN5530B Housing
FKN5708A Flat Cable
FKN5809A Shielded Bus
FLN4604B Hardware Kit
FLN5013A Chassis
FRN1767A Bus Expansion Interface (2 used)

V026AE Slave Operation (for all other models)

FHN5530B Housing
FKN5709A Flat Cable
FKN5809A Shielded Bus
FLN4604B Hardware Kit
FLN5013A Chassis
FRN1767A Bus Expansion Interface (2 used)

V026AF Slave Operation (for AMRTU)

add FHN5538A Frame
FKN5710A Flat Cable
FKN5769A Shielded Bus
FLN4563A Mounting Kit
FRN1767A Bus Expansion Interface (2 used)

V034AA 48 V dc Positive Ground Operation

add FHN5538A Frame
FPN1611A Power Supply
FRN1734A Radio Interface (MRI) for 48 V
-48 V Power Supply Instruction Section

omit FLN1477A Radio Interface (MRI)

V051AG 19-inch rack mount MRTU without radio

add	FHN5538A	Frame
	FKN5702A	Flat Cable
	FLN1459A	External Radio Interface Module (XRI)
	FLN4563A	Module Mounting (2 used)
	FLN4659A	Label Kit
	FLN4847A	Power Supply
	FLN5008A	Chassis
	FLN6089C	115 V ac Transformer
	FLN6161A	Tooling Kit
	NLN7401A	HT440 Battery Charger
omit	FHN7819A	Housing
	FKN5804A	Communication Cable
	FLN4604B	Hardware Kit
	FLN4666A	Battery, 5 Ah
	FLN4919A	Hardware Kit
	FLN4940A	Radio Mounting Kit
	FLN4948A	Radio Interface Board
	FLN4977A	Tamper Switch
	FPN1608B	Power Supply

V051AH 19-Inch Rack Mount MRTU with Radio

add	FHN5538A	Frame
	FKN5702A	Flat Cable
	FLN4893A	Antenna Panel
	FLN4563A	Mounting Module
	FLN4659A	Label Kit
	FLN4847A	Power Supply
	FLN6089C	115 V ac Transformer
	FLN6161A	Tooling Kit
	NLN7401A	HT440 Battery Charger
omit	FHN5509A	Battery Cover
	FHN7819A	Housing
	FKN5601A	Antenna Cable
	FLN4666A	Battery, 5 Ah
	FLN4604B	Hardware Kit
	FLN4919A	Hardware Kit
	FLN4634A	Tamper Switch
	FPN1608B	Power Supply

V100AA 4-Interpose Relays

add	FRN1660A	10 A 4-Interpose Relays module

V100AB 4-Interpose Relays

add FRN1733A 2 A 4-Interpose Relays module

V100AC 4-Interpose Relays (for AMRTU)

add FLN4563A Mounting Module
FRN1660A 10 A 4-Interpose Relays module

V100AD 4-Interpose Relay (for AMRTU)

add FLN4563A Mounting Module
FRN1733A 2 A 4-Interpose Relays Module

V114AF Omit Battery

omit FLN4666A Battery, 5 Ah
FLN4919A Hardware kit

V115AC Status Input Expansion with Display (for AMRTU)

add FLN4450A Label Kit
FLN4563A Mounting Module
FRN1659A Status Input Module With Display

V115AD Status Input Expansion with Display

add FRN1799A Status Input Module (SI-8)

V116AA 4-Control Output Expansion

add FLN1464A 4-Control Output Module

V116AB 4-Control Output Expansion (for AMRTU)

add FLN1464A 4-Control Output Module
FLN4402A Label Kit
FLN4563A Mounting Module

V117AA 8-Control Output Expansion

add FLN1468A 8-Control Output Module

GENERAL

1. GENERAL DESCRIPTION

The INTRAC 2000 MRTU (Modular Remote Terminal Unit) is a two-way unit ideally suited for monitor and control functions at remote locations. The MRTU is fully compatible with the INTRAC 2000 family of products.

The MRTU can communicate with any of the INTRAC 2000 central stations and/or with other MRTUs by means of securely coded messages superimposed over FM radio or microwave transmissions, or over wirelines.

A typical INTRAC 2000 system is comprised of remote units communicating with a central station and/or with each other. Figure 1, Typical System shows a typical system, assuming all remotes belong to the MRTU family.

1.1 MRTU ADDRESSING

The messages transmitted by and received from the MRTU are constructed of codewords. Each codeword includes an address identifying the specific MRTU.

The MRTU address has two parts: the system address and the station address. This structure allows several users to share the same communication channel (radio frequency or wireline), each of them utilizing their own system. The systems are distinguished from each other by the system address which is unique for each system; the station address identifies each MRTU in the

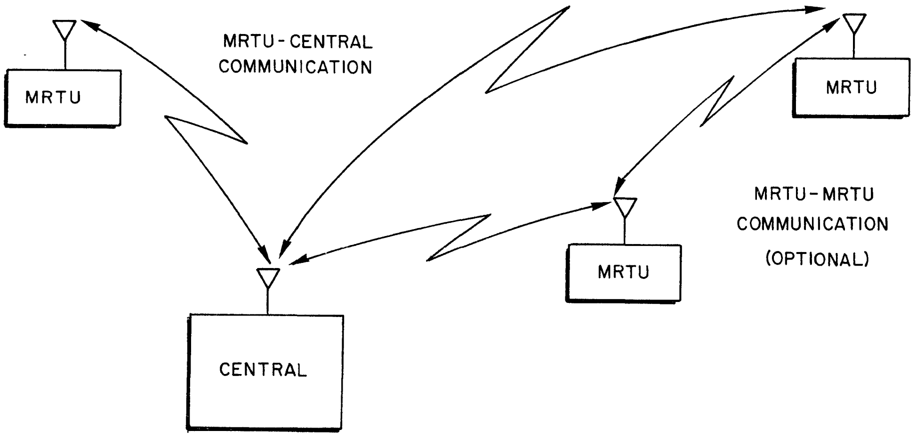

Figure 1. Typical System

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V117AB 8-Control Output Expansion (for AMRTU)

add FLN1468A 8-Control Output Module
FLN4403A Label Kit
FLN4563A Mounting Module

V118AA Analog Output

add FLN1463A 2-Analog Output Module

V118AB Analog Output (for AMRTU)

add FLN1463A Analog Output Module
FLN4401A Label Kit
FLN4563A Mounting Module

V140AA Audio Amplifier

add FRN1744A Audio Amplifier

V209AJ Digital Private Line (for models with Maxtrac radio)

V226BP Wireline Operation (for AMRTU)

add FKN5702A Flat Cable
FLN1459A External Radio Interface Module (XRI)
FLN4405A XRI Label Kit
FLN4563A Mounting Module (2 used)
FLN4599A Wiring Kit
FLN4656A Label Kit
FRN1690B AMRTU Wireline Interface

V226BQ Wireline Adapter

add FLN1467B Wireline Interface Module
FLN4619A Jumper Kit

V227CA Low Band Radio

add FKN5774A Antenna Cable
FKN5775A Radio Cable
FLN4991A Bracket
6802954G71 Instruction Manual

V230BA Private Line (for models with HT440 radio)

V230BC Private Line (for models with Maxtrac radios)

V251AE 230 V, 50 Hz Operation

add	FLN6090A 230 V ac Transformer kit
omit	FLN6089B 115 V ac Transformer kit

V251AF 230 V ac Operation

add	FLN4669A 230 V ac Operation

V265AJ 8-Input Protection

add	FRN1641A Input Protection Module (IP-8)

V274AQ 12 V dc Operation (MRTU Plus models)

omit	FLN4666A Battery, 5 Ah FLN4919A Hardware Kit FPN1608B Power Supply

---

V274AP 12 V dc Operation (MRTU models)

add	FHN5509A Battery Cover
omit	FLN5879B 115 V Transformer NLN7401A HT440 Battery charger

---

V275AJ Timeout Timer

add	TRN8618A Timeout Timer

V275AK Timeout Timer (for models with Maxtrac radios)

V276AC Small Metal Housing

add FHN7819A Housing Kit
FLN4604B Hardware Kit
FLN4634A Tamper Switch
FLN5008A Chassis
FLN6089C 115 V ac Transformer
68P02962G20 Instruction Manual

omit FLN4954A Panel Mounting
FLN5879B 115 V ac Transformer
68P02965G50 Instruction Manual

V277AC Voice and Radio Interface (VRI)

add FRN1662A Voice and Radio Interface Module

V278AB Analog Input (AI-6)

add FLN1450A 6-Analog Inputs Module

V278AC Analog Input (for AMRTU models)

add FLN1450A 6-Analog Inputs Module
FLN4398A Label Kit
FLN4563A Mounting Module

V328AL Battery Expansion

add FLN4666A Battery, 5Ah
FLN4998A Power Cable

V349AA Change Radio Frequency

add FUD1841AA Radio, 25 W, 136-162 MHz

omit FUD1841AB Radio, 25 W, 146-174 MHz

V377AA 6 Status and 2 Control

V378AA 6 Status and 1 Control

ACCESSORIES

FRN1785A	Field Configuration Program
TMN6057A	Handset for use with V227AC Voice and Radio Interface
TLN4505A	Handset Hangup Cup
HSN4013A	External Speaker

ADD-ON/SPARE MODULES

FRN1691A	MRTU Basic Module without Power Supply Charger
FRN1799A	8-Status with Display Module
FRN1641A	8-Input Protection Module
FLN1450A	6-Analog Inputs Module
FLN1464A	4-Control Relays Module
FRN1733A	4-Interpose Relays (2A)
FRN1660A	4-Interpose Relays (10A)
FLN1463A	2-Analog Outputs Module
FLN1467B	Wireline Interface Module
FRN1662A	Voice and Radio Interface Module
FKN5710A	Expansion Cable

ADD-ON/SPARE MODULES FOR AMRTU

FRN2004A	AMRTU Basic Module
FRN1697A	8-Alarm Expansion with Display
FRN1670A	6-Analog Inputs Module
FRN1674A	4-Control Relays Expansion
FRN1672A	2-Analog Outputs Module
FLN1477A	Microwave Radio Interface
FRN1676A	Master Station Interface
FRN1677A	External Radio Interface
FKN5710A	Expansion Cable

MANUALS

68P02965G85	MRTU Technical Information
68P02964G20	MRTU Plus Technical Information
68P02964G98	Protocol Reference Guide
FLN4573	Set of Low Power Radio Manuals
68P80101W76	25 Watt VHF Radio Manual
68P02920G15	15 watt UHF Radio Manual
68P02938G70	928 MHz Radio Manual

system. The address capacity allows four systems (with system addresses 0 to 3), each with 512 station addresses as shown in Figure 2, Four Systems.

1.2 INPUTS/OUTPUTS

A functional block diagram of the MRTU illustrating the interface to the customer's equipment and to the communication channel, is shown in Figure 3, Input/Output Connections.

The MRTU can monitor the following types of inputs:

- Simple (discrete) inputs: used to monitor status of customer equipment and alarms. Also used for counter-based functions.
- Analog inputs: current (4-20 mA) or voltage (±1 V) inputs indicating measured variables such as pressure and temperature.

The MRTU can control the following types of outputs:

- Relay (discrete) outputs: provided to the user in dry-contact form. Relays are available in the following modes: momentary, latch, common latch and general purpose.

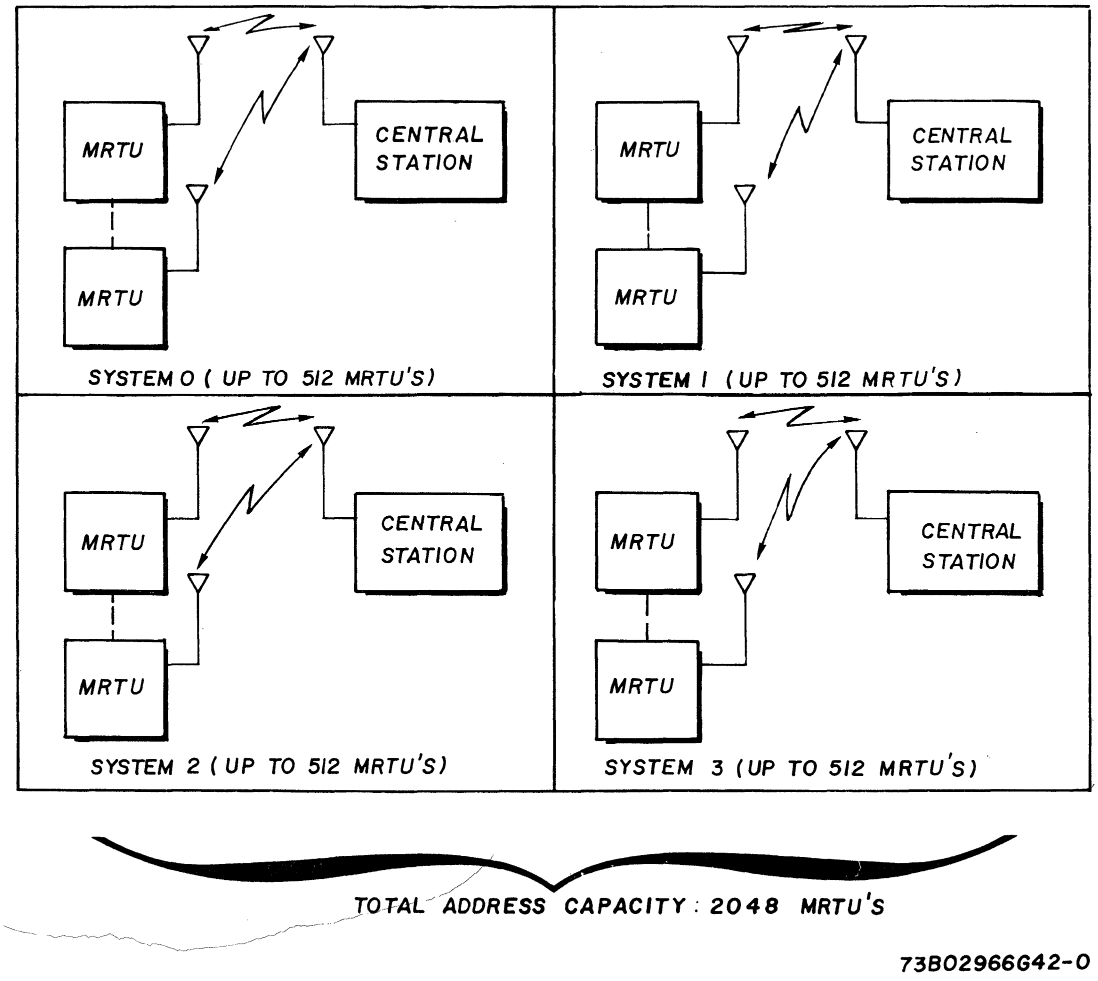
MRTU
CENTRAL STATION
MRTU
SYSTEM 0 (UP TO 512 MRTU'S)
MRTU
CENTRAL STATION
MRTU
SYSTEM 1 (UP TO 512 MRTU'S)
MRTU
CENTRAL STATION
MRTU
SYSTEM 2 (UP TO 512 MRTU'S)
MRTU
CENTRAL STATION
MRTU
SYSTEM 3 (UP TO 512 MRTU'S)
TOTAL ADDRESS CAPACITY : 2048 MRTU'S
73B02966G42-0

Figure 2. Four Systems on One Communication Channel

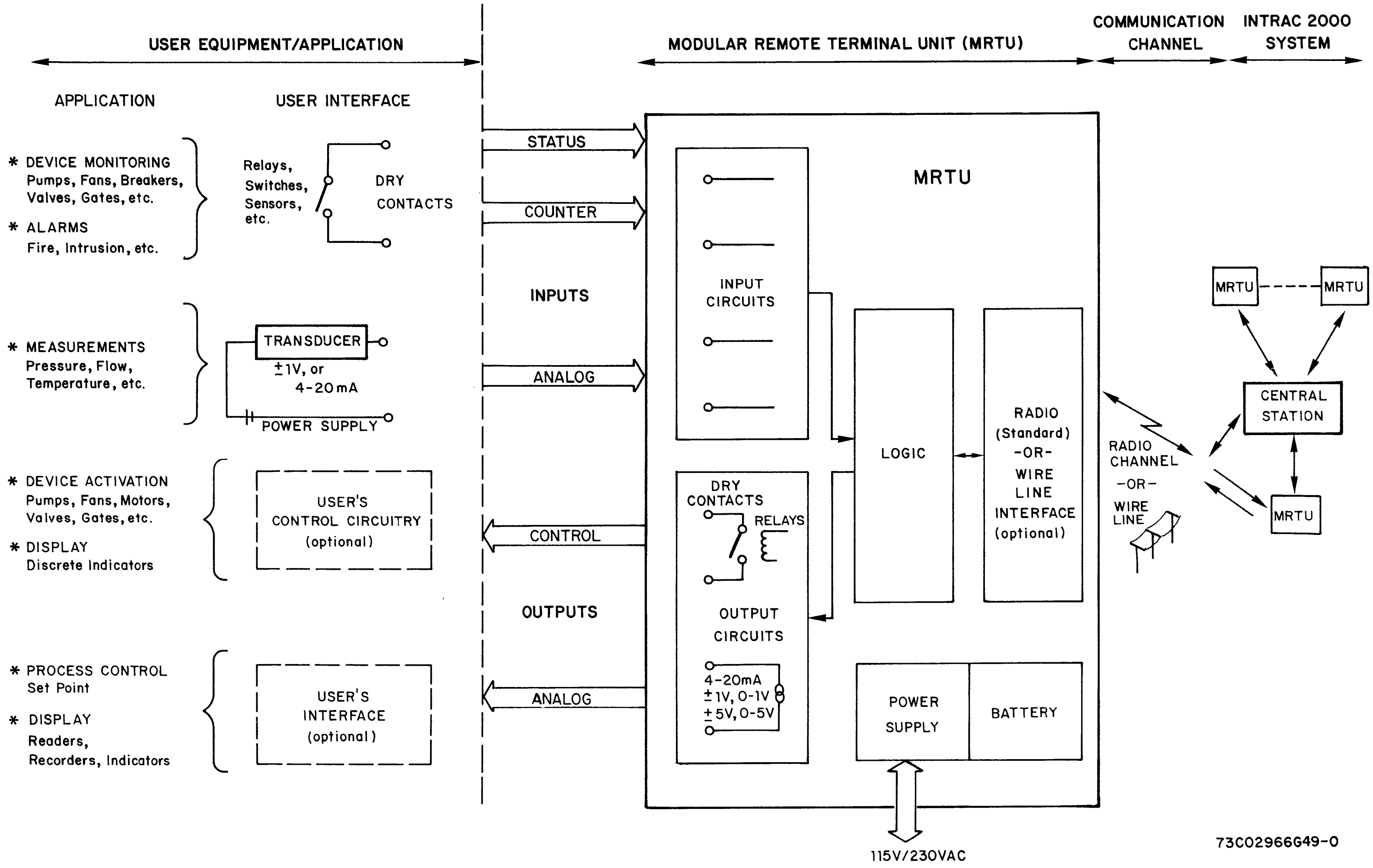

Figure 3. Input/Output Connections

- Analog outputs: provided in the form of current (4-20 mA) or voltage (± 1 V, ±5 V, 0-1 V, 0-5 V).

The MRTU is a modular product which can be ordered with the correct number and types of inputs/outputs based on the requirements of the application.

The MRTU Basic module and several of the expansion modules are microprocessor based. A common bus, provided by the interconnecting flat cable, provides internal communication between modules.

All units are factory supplied with predefined (default) parameters; parameters can be easily modified in the field.

Several models are available in various radio bands and with various radio output power; a model without radio is also available.

2. MODELS

All MRTU models include the MRTU Basic module. This module is available with the following I/O capacities:

a. 8 status inputs, 1 control output (standard model)

b. 6 status inputs, 2 control output (option V377).

c. 6 status inputs, 1 control output, 1 analog input (option V378).

The I/O capacity of the MRTU can be enlarged by adding MRTU expansion modules, which are also available as field add-ons (consult model complements and options pages in this manual).

The MRTU family breaks down into three main groupings: the MRTU, the MRTU PLUS and the AMRTU.

2.1 MRTU

The MRTU is available with low power VHF and UHF radios only.

Supplied on a mounting plate for wall mounting, a NEMA-4 outdoor housing option (V276) is available if required. Once the housing option is added, the capacity can be expanded by adding up to four expansion modules.

A transformer, charger and 450 mAh Ni-Cad battery are supplied with the MRTU.

2.2 MRTU PLUS

The MRTU PLUS is available with low power and high power UHF and VHF radios; trunked radio and 900 MHz radio models are also available.

The MRTU PLUS is available in two NEMA-4 housing options: the small housing allows the addition of up to four expansion modules; the large housing allows the addition of up to seven expansion modules.

The MRTU PLUS is supplied with a true power supply and battery pack. The power pack provides for ac operation and backup upon ac power failure.

2.3 ANALOG MICROWAVE REMOTE TERMINAL UNIT (AMRTU)

The AMRTU provides MRTU monitor and control functions via analog microwave radio channels. The AMRTU is supplied in a 19-inch rack mounted chassis which provides room for the AMRTU Basic Module and eight additional expansion modules.

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INSTALLATION FOR MODELS WITHOUT HOUSING

1. INTRODUCTION

The installation procedure described herein is for MRTU models F6014, F6023 and F6053 (without the housing option V276); installation for models with housing are covered in a separate chapter. We recommend that the installation be done by an experienced technician, contractor or the equivalent.

Carefully inspect the MRTU immediately upon receiving it. Notify the shipper of any damages incurred in transit.

2. UNPACKING

Carefully unpack the unit components. The components, as illustrated in Figure 1, Components include the following: one mounting plate, one basic MRTU module, one 24 V ac transformer, one transformer mounting plate and one antenna cable.

Note that the MRTU basic module is shipped with the Ni-Cad battery connected to the radio. To avoid power drain of the battery, the radio is shipped with a piece of cardboard separating the battery from the radio unit. To remove the cardboard, unfasten the battery screw at the bottom of the radio. After removing the cardboard, replace the battery and fasten the battery screw.

We recommend that the battery be charged for 24 hours prior to installation. To do so, plug in the MRTU basic module via the 24 V ac transformer with the battery in place (battery charges automatically).

3. MOUNTING

This procedure is for MRTU models without housing. Therefore, it is best to install the unit indoors. If indoor installation is not possible, a suitable enclosure should be provided.

Before installation, verify that the mounting surface is large enough by reviewing the mounting plate dimensions provided in Figure 2, Dimensions. Choose a smooth and stable mounting surface; clean the surface prior to installation.

Step 1. Affix two screws to the mounting surface, at a vertical distance equivalent to the distance between the two mounting holes on the mounting plate (the holes at the extreme edges of the mounting plate).

Step 2. Attach the MRTU basic module to the mounting plate by means of the two captive screws provided for that purpose. The screw at the top is accessed by opening the latch door at the top of the module. The second screw is located at the bottom of the module.

Step 3. Attach the mounting plate (after MRTU basic module has been attached) to the surface by inserting the mounting holes onto the screws.

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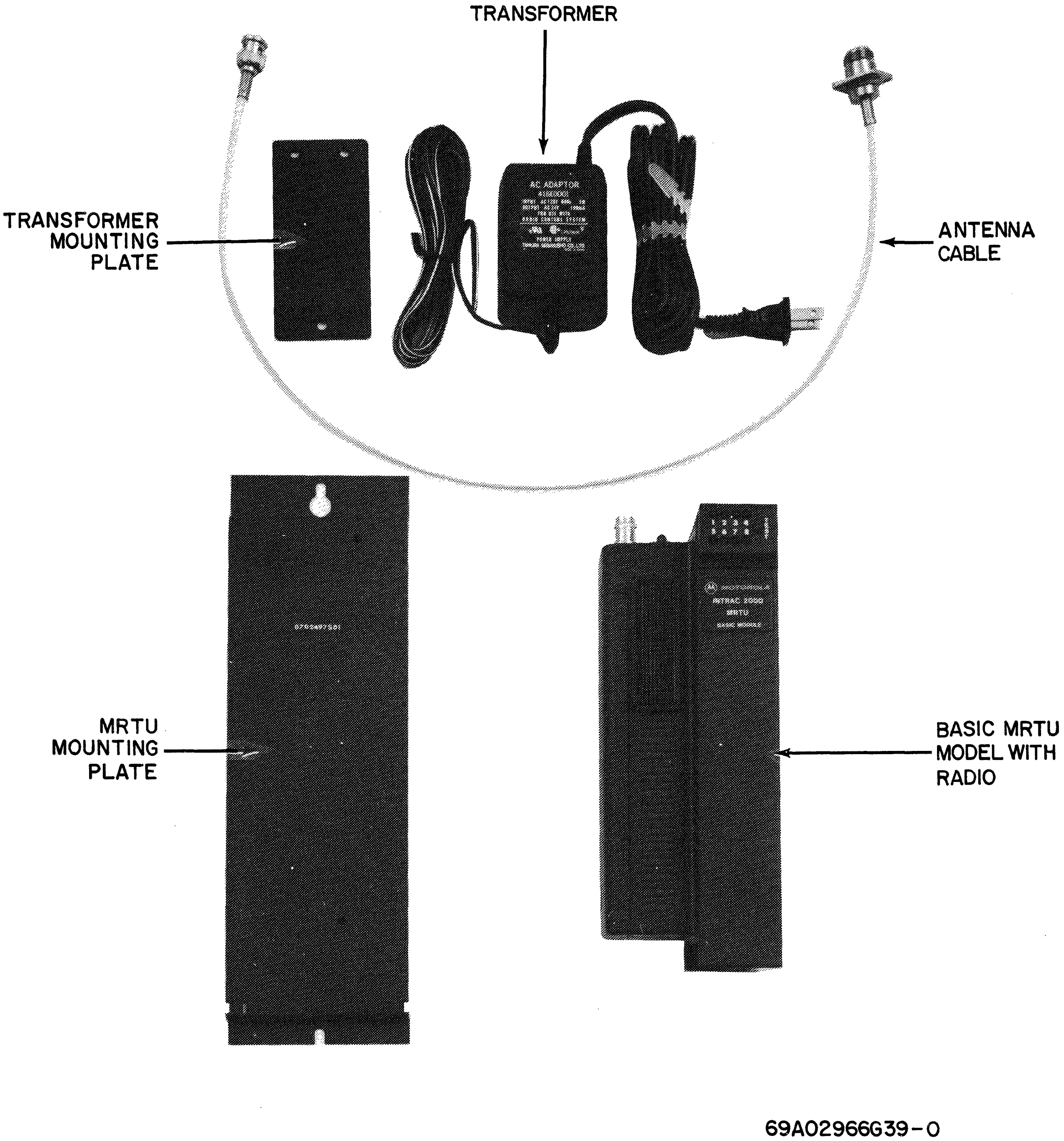
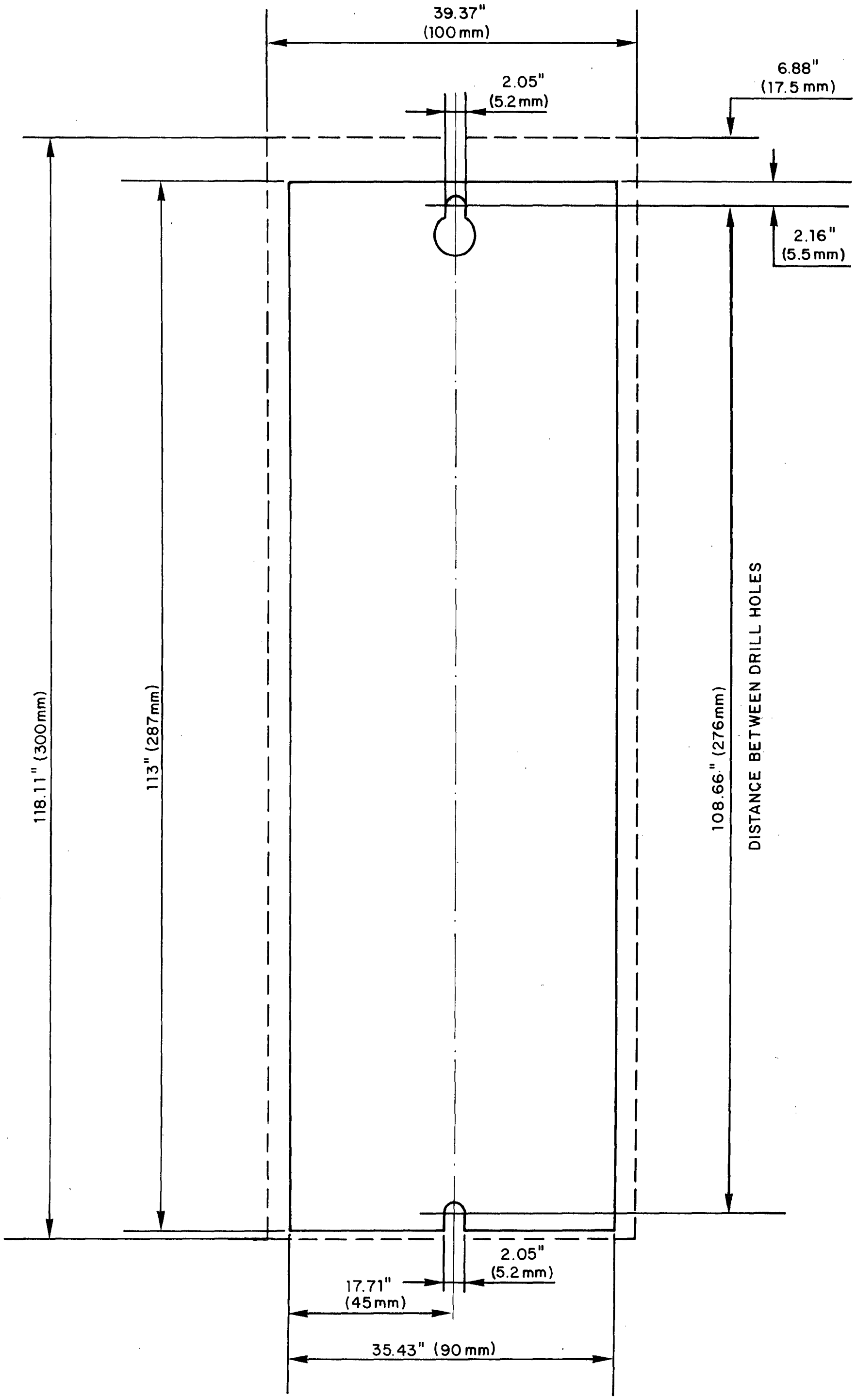


Figure 1. Components



THE AREA WITHIN THE DOTTED LINES
REPRESENTS THE MINIMUM CLEARANCE
(ON THE WALL) FOR INSTALLATION.

MAXIMUM SCREW SIZE IS 5 mm.

69C02966G28-0

Figure 2. Dimensions

The mounting plate must be mounted with the serial number (printed on the mounting plate) facing towards you.

Step 4. Attach the antenna to the BNC connector at the top of the radio. Use the N-to-BNC cable provided, if necessary.

Step 5. Make the appropriate wiring connections to the user connector (plug-in) terminal strip (numbered 1-14); according to Table 1. User Connections.

NOTE

> Make sure the unit is well grounded via pins 7 and 12 of the terminal strip. The mounting plate must also be connected to ground.

Step 6. Attach the provided transformer mounting plate to the wall in any desired location. Mount the transformer on the transformer mounting plate.

Step 7. Connect the transformer cable (two-wires) to the user connector terminal strip, pins 13 and 14. Plug in the transformer power cable to the ac outlet (110 V or 220 V).

4. INITIAL TEST

Refer to Figure 3, MRTU Basic Module.

Step 1. Confirm proper radio operation by pressing the PTT switch located on the side of the radio. The radio LED should light throughout the test transmission.

Step 2. Press the Display Test pushbutton, located on the latch door of the basic module, for about three seconds. The eight status display LED's will light for one second, after which all LED's with the exception of LED number 7 will turn off. This indicates proper functioning of the unit. Should any additional LED's remain lighted, consult the Diagnostic section of the MRTU Service Manual, 68P02957G60.

If an INTRAC C1570B or C1571B Test Set is available, perform the following steps.

Step 3. Connect the INTRAC C1570B or C1571B Test Set to the MRTU test set connector J2, located underneath the latch door of the module.

Step 4. Send an INT(errogation) request to the MRTU from the Test Set, by setting the appropriate addresses and initiating an INT request. The MRTU should respond by transmitting all status and analog groups.

Step 5. Send a control group to the unit and confirm proper operation of the relays. Initiate a COS transmission from the unit and confirm reception at the test set.

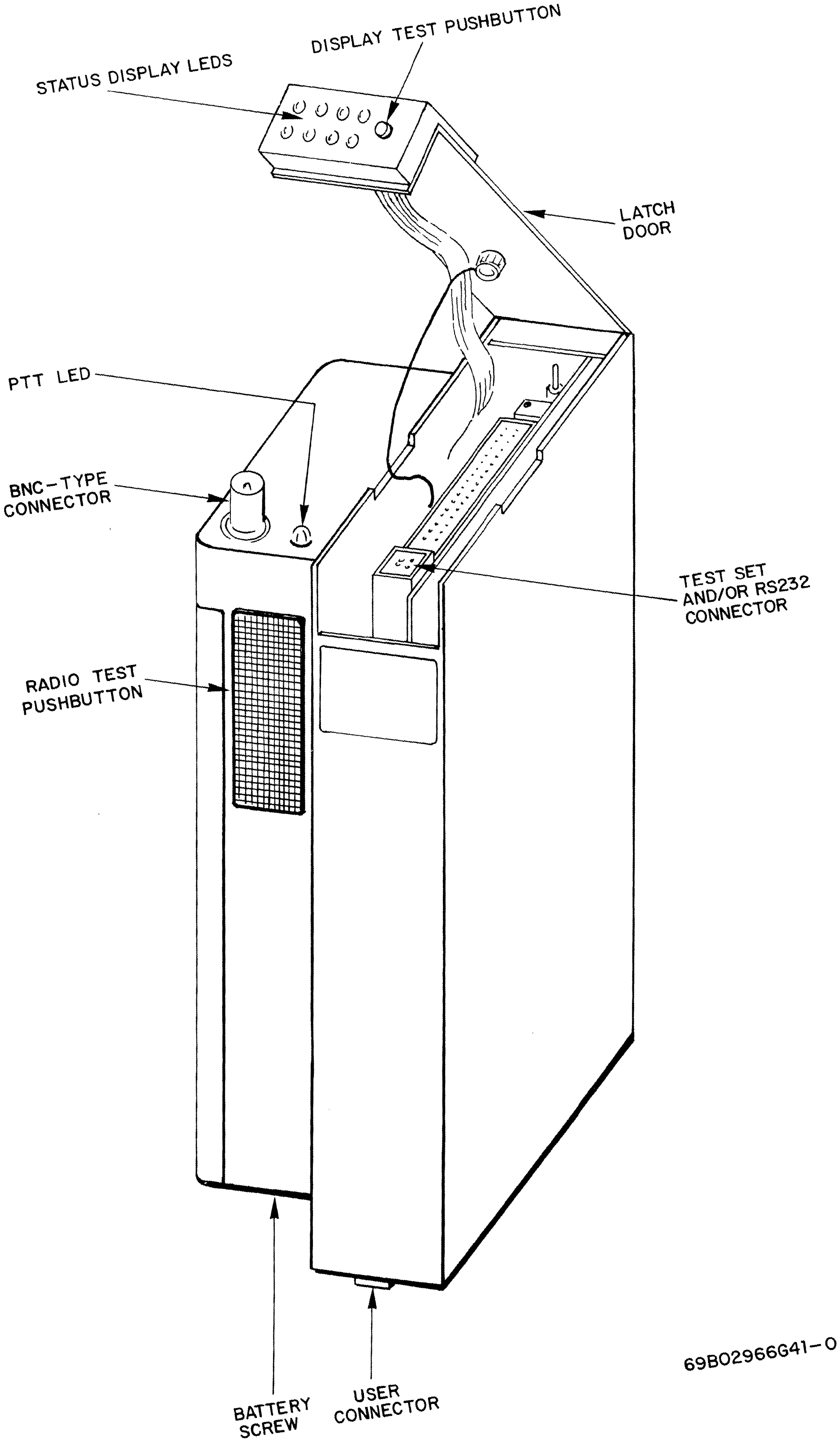


Figure 3. MRTU Basic Module

Table 1. User Connections (J6)

Pin Number	Function
1	Relay K1 (N.O.)
2	Relay K1 (Common)
3	Status Input 1 or Relay K2 (N.O)
4	Status Input 2 or Relay K2 Common)
5	Status 3
6	Status 4
7	Ground
8	Status 5
9	Status 6
10	Status 7 or Analog Input (+)
11	Status 8 or Analog Input (-)
12	Ground
13	24 V ac
14	24 V ac

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INSTALLATION FOR MODELS WITH HOUSING

1. INTRODUCTION

The installation procedure described herein is for MRTU and MRTU PLUS models supplied with housing. We recommend that the installation be done by an experienced technician, contractor or the equivalent.

Carefully inspect the MRTU immediately upon receiving it. Notify the shipper of any damages incurred in transit.

2. MOUNTING

Before installation, verify that the mounting surface is large enough by reviewing the housing dimensions provided in Figures 1 and 2, Dimensions. Choose a smooth and stable mounting surface.

A drainage hole is located at the bottom of the housing to allow proper drainage.

Refer to Figures 3 and 4, Inside View.

Step 1. Fasten the four mounting brackets (supplied with the unit) to the four screws protruding from the back of the housing, by means of the four washers supplied for that purpose.

Step 2. Affix four screws to the mounting surface, at the distances between the appropriate mounting bracket holes (refer to Figures 1 and 2).

Step 3. Mount the unit on the mounting surface by placing the mounting bracket holes on the four screws. Fasten the unit securely to the mounting surface.

Step 4. Attach the antenna to the N-type connector at the bottom of the housing.

Step 5. Verify that all expansion modules are properly connected to the basic MRTU module. Wire the user terminal strip of each module according to the tables provided in Appendix 1 of this manual.

NOTE

Make sure that the unit is well grounded. Connect the ground (preferably a buried water pipe or any direct earth ground) via a #14 AWG wire to the screw marked with the ground symbol located on the inside of the housing (the screw is accessed by temporarily removing the plastic covering the ground screw. Use the spare bolts provided on the back of the housing in order to fasten ground wires securely in place. The protective ground of each expansion module should also be connected to the ground screw.

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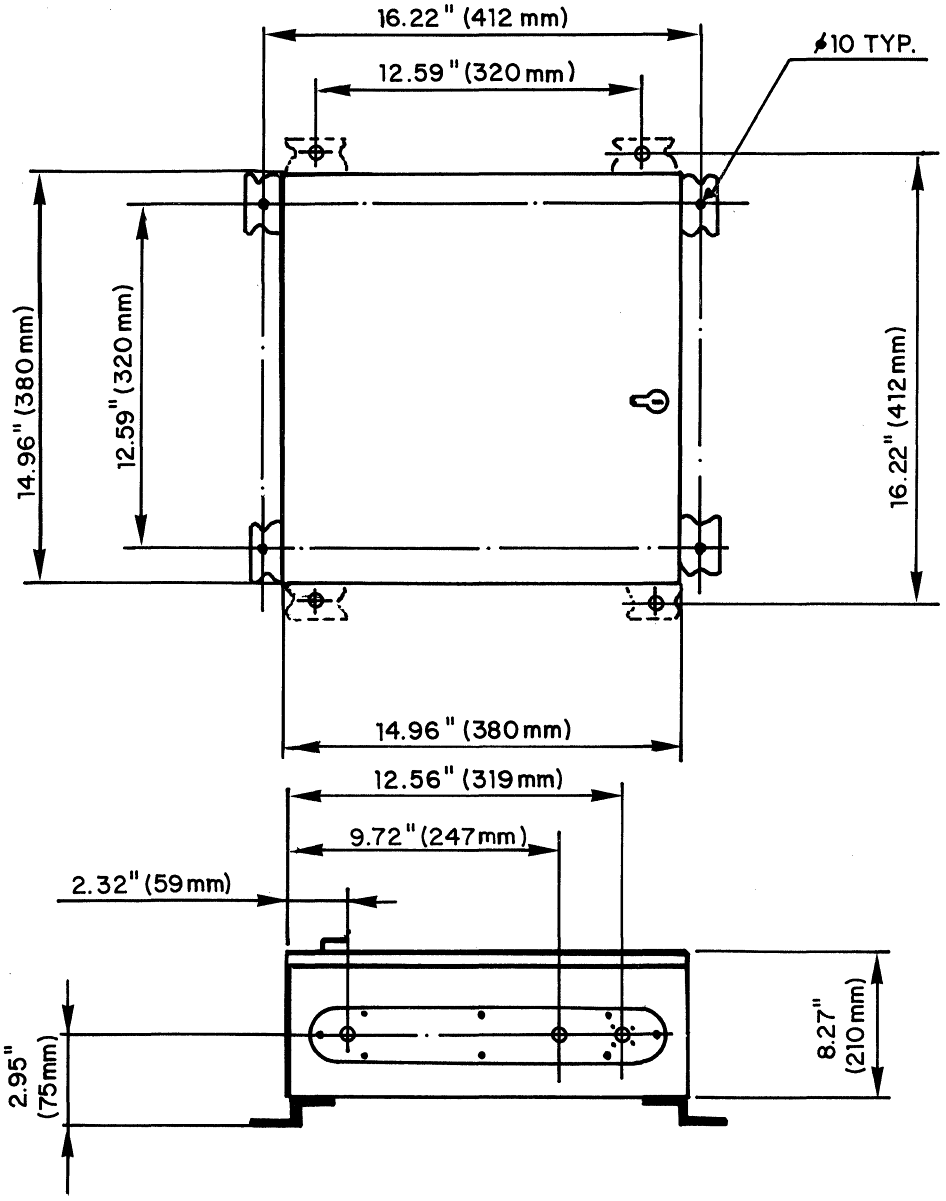

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Figure 1. Dimensions-Small Housing

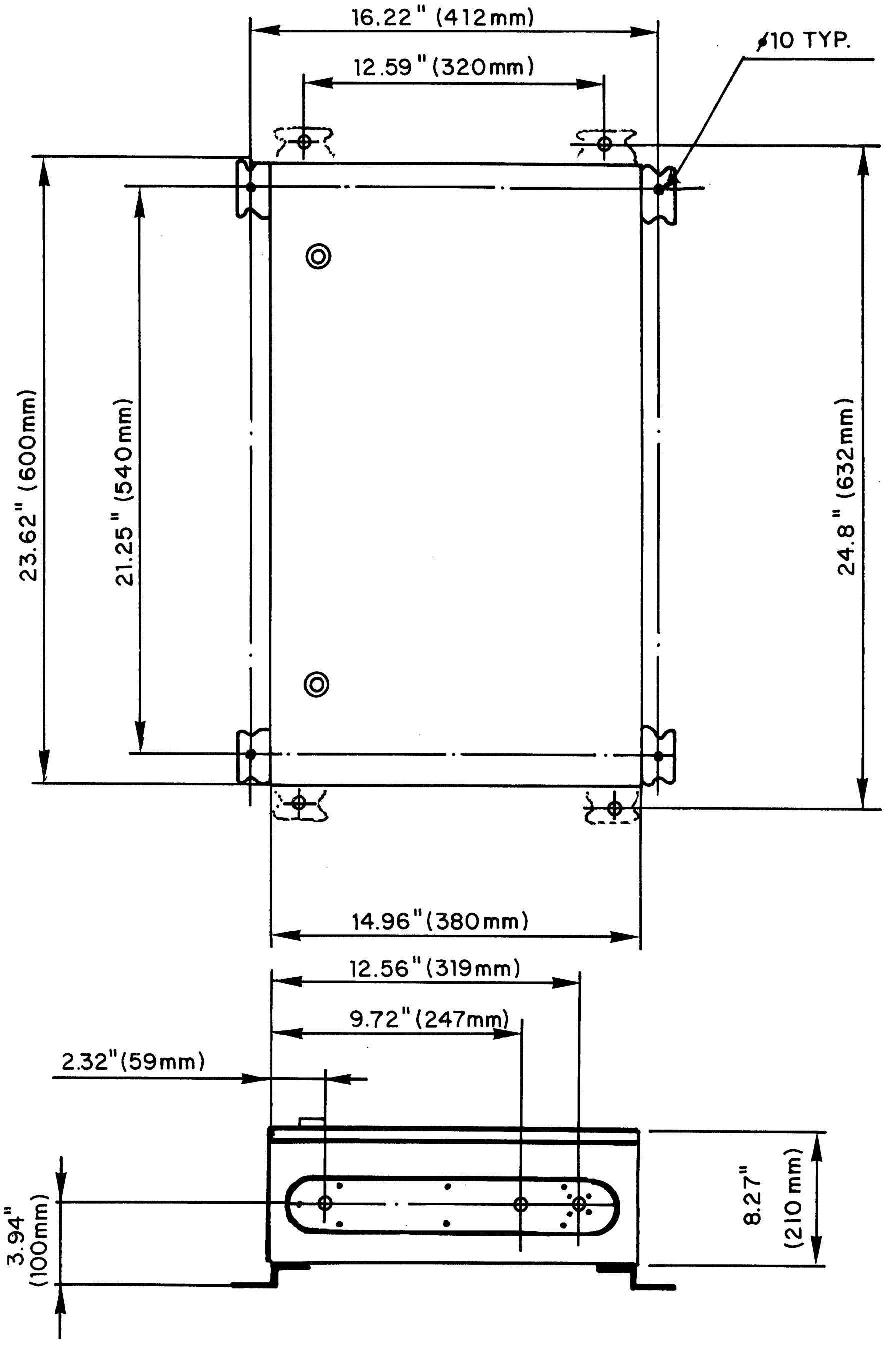

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Figure 2. Dimensions-Large Housing

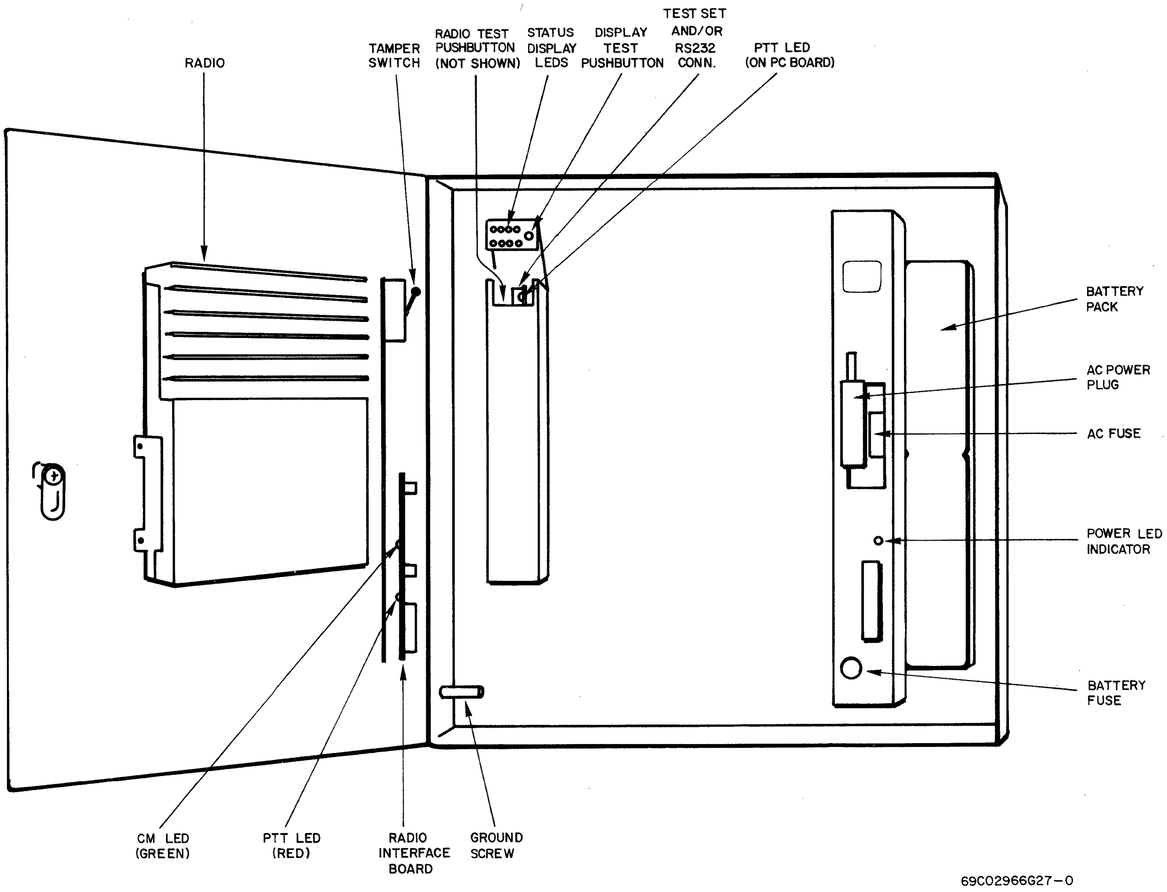

Figure 3. Inside View-Small Housing

For models F6014, F6023, F6053 with V276 option and models F6514, F6523, F6553 with the V051 (19" rack) option:

Step 6. Plug in the transformer power cable to the 110 V ac outlet (220 V ac for option V251). The LED Power indicator will light.

For all other models refer to Figure 3 or 4.

Step 6. Verify that the ac fuse is in place; the ac fuse (2 A SB for 110 V models; 1 A SB for 220 V models) is located at the right side of the ac power plug receptacle and is accessed by lifting the mini-latch door.

Step 7. Connect the ac power plug to the ac power plug receptacle and to the ac outlet (110 V or 220 V). Insert the battery fuse (10 A SB) into the receptacle marked "battery." The LED Power indicator will light.

NOTE

> The battery pack is fully charged when shipped from factory. The battery pack can, however, drain during shipment. It is therefore recommended to charge the battery pack (by normal powering of the unit) for 8 hours prior to regular use of the unit.

3. INITIAL TEST

The following test should be conducted after completing the mounting procedure.

Refer to Figure 3 or 4.

For models F6014, F6023, F6053 with V276 option and models F6514, F6523, F6553 with the V051 (19"rack option):

Step 1. Press the PTT switch located on the side of the radio. Upon releasing the pushbutton, an MRTU transmission is initiated and the Radio LED will light during transmission.

Complete Steps 2-6.

For all other models:

Step 1. Press the Radio Test pushbutton located inside the MRTU basic module (on the PC board); the Radio Test pushbutton is accessed by opening the basic module latch door. Upon releasing the pushbutton, an MRTU transmission is initiated. The red LED located on the Radio Interface board will light during transmission, indicating proper radio operation.

Step 2. Press the Display Test pushbutton located on the latch door of the MRTU basic module for about three seconds. The eight status display LED's will light for one second, after which all LED's with the exception of LED number 7 will turn off. This indicates proper functioning of the unit. Should any additional LED's remain lighted, consult the Diagnostic section of the MRTU Service Manual 68P02957G60.

Step 3. Connect an INTRAC C1570B or C1571B Test Set to the Test Set Connector (connector J2) located underneath the latch door of the basic module.

Step 4. Send an INT(errogation) request to the MRTU from the test set, by setting the appropriate addresses and initiating an INT request. The MRTU should respond by transmitting all status and analog groups.

Optionally, if a test set is unavailable, hit the Radio Test pushbutton to confirm that the unit is transmitting all inputs.

Step 5. Send an EXECUTE command to the MRTU. Verify proper operation of the relays.

Step 6. If analog output modules (AO-2) are a part of the MRTU, send analog output controls to the MRTU.

Step 7. If analog inputs modules (AI-6) are a part of the MRTU, change the value of each analog input and observe that a transmission occurs whenever the analog value crosses the delta limits.

4. WIRING

4.1 GENERAL

All wires that are connected to user equipment, as well as the antenna wire, must be passed through the opening provided for this purpose at the bottom of the metal housing.

Pass the wires on both sides of the mounting plate as specified below, in order to shield and protect them against EMI and RF noise. There are four wire categories:

a. AC power input;

b. antenna cable;

c. Interpose Relay Output (IR-4)and Input Protection Input (IP-8 option);

d. inputs and outputs of the MRTU modules.

It is recommended that types a and c wires, which are prone to noise, be passed on one side of the mounting plate. The antenna cable (type b) and the inputs and outputs of the MRTU modules (type d) should be passed on the other side of the mounting plate to eliminate noise-reception problems.

All wires should be tied in place after the appropriate connections are made. Plastic wire-fastener strips should be used for this purpose; use the specially drilled holes located on both side panels of the mounting plate.

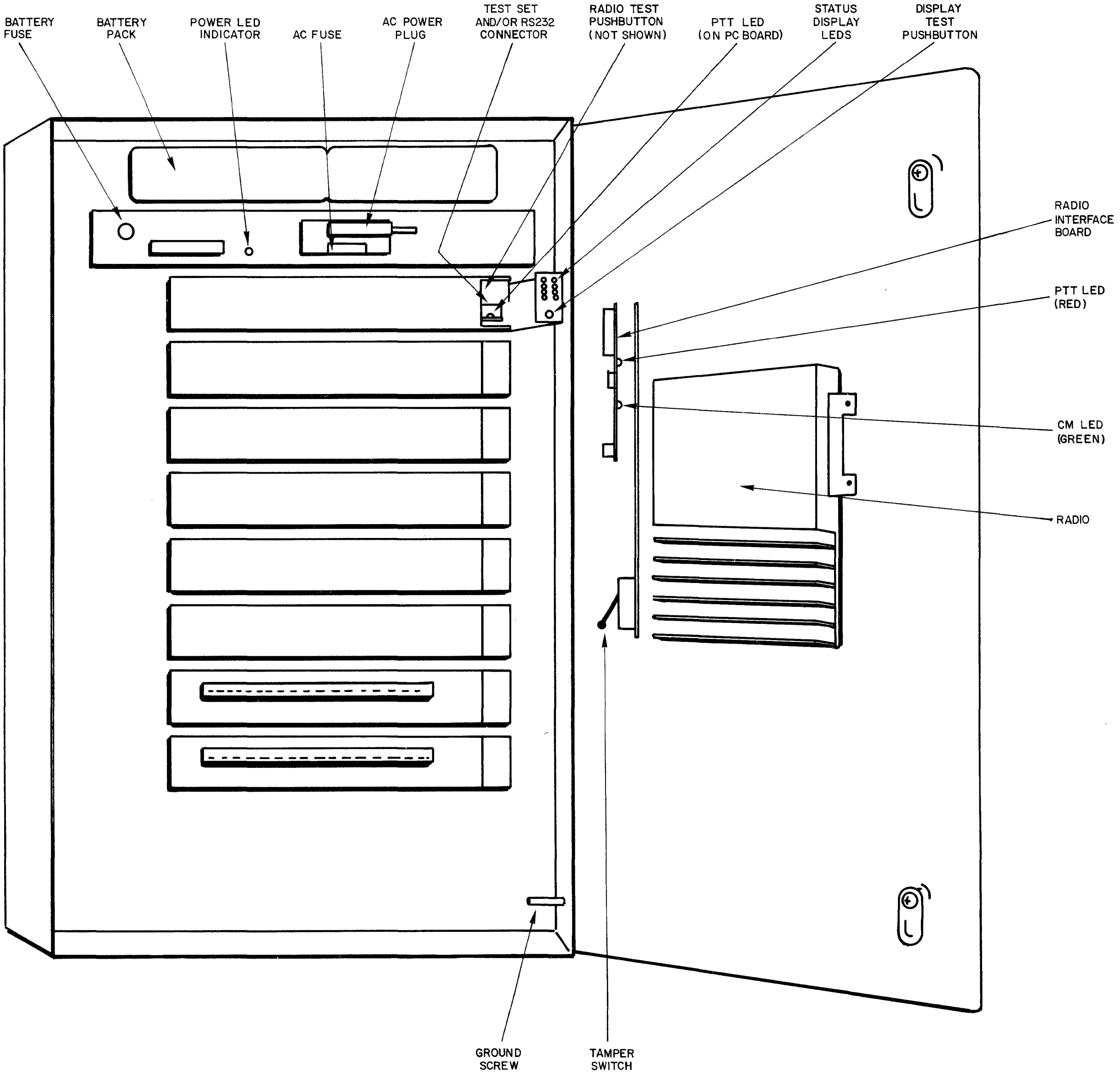

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Figure 4. Inside View - Large Housing

4.2 EXPANSION MODULE I/O CONNECTIONS

Make the proper connections between the expansion modules and customer equipment as specified for each module in Appendix 1 of this manual.

NOTE

> Before connecting customer equipment to the expansion modules, power the unit for about fifteen seconds (until the PTT LED turns off) in order to reset the control outputs.

4.3 POWER SIGNALS

Not applicable to models F6014, F6023, F6053 with V276 option and models F6514, F6523, F6553 with V051 (19" rack) option.

4.3.1 Power Fail Signal

The Power Fail (PF) signal is factory set. To disable PF monitoring, disconnect the orange wire between the PS-8 module and pin 14 of the MRTU basic module.

4.3.2 Low Battery Signal

To enable monitoring of the Low Battery signal, connect the LB output of the power supply to any status input pin in the user connector terminal strip.

For models F6014, F6023, F6053 with V276 option and models F6514, F6523, F6553 with the V051 (19" rack) option, the Low Battery signal is reported internally via the MRTU basic module.

5. CONNECTION OF ADD-ON EXPANSION MODULES

The following procedure is required when adding an expansion module to an existing MRTU in the field.

Step 1. Modify the database of the existing MRTU with a new database which includes the add-on modules.

Step 2. Replace the existing flat cable with a new flat cable containing the appropriate number of connectors.

Step 3. Disconnect the power to the MRTU (ac and battery backup).

Step 4. Set jumpers and DIP switches according to the instruction manual of the add-on modules.

Step 5. Connect the add-on modules to the flat cable connectors and power the MRTU.

Step 6. Execute the Initial Test as described in section 3 of this chapter.

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INSTALLATION FOR AMRTU

1. PRELIMINARY

Carefully inspect the Analog Microwave Remote Terminal Unit (AMRTU) upon receipt and notify the shipper immediately of any damage incurred in transit.

CAUTION

> The AMRTU operates on a positive ground supply. The use of instrumentation for the maintenance of any module within the AMRTU requires correct grounding of the instrumentation.
>
> The low input of such instrumentation should be connected directly to the battery ground (+ of the battery). A ground test point is located on the MRI panel-see Figure 2. Do not attempt to connect a low input probe to an MRTU module point marked "GND" (it is -24 V).

2. AMRTU DEFAULT SETTINGS

The AMRTU is factory set in the default configuration listed below. Non-default configurations can be set during installation in field, or in factory, upon request.

Baseband Slot: 4-8 kHz default. 8-12 kHz jumper selectable.

Operation: 2-way default. 3-way jumper selectable.

Out 1 TX Level: -30 dBm default. -26 dBm to -56 dBm adjustable.

Out 2 TX Level: -30 dBm default. -26 dBm to -56 dBm adjustable.

IN 1 RX Level: High (-13 dBm to -33 dBm) default. Low (-33 dBm to -53 dBm) jumper selectable.

In 2 RX Level: High (-13 dBm to -33 dBm) default. Low (-33 dBm to -53 dBm) jumper selectable.

3. MOUNTING

3.1 MODULE MOUNTING

Each module can be mounted separately on the chassis via the module mounting and screw provided in the FLN4563 Mounting Kit (see Figure 3. Module With Mounting).

3.2 AMRTU MOUNTING

Step 1. Verify that the rack space is sufficient for the AMRTU module.

NOTE

> For easy module access, it is recommended to leave a space of approximately 2" above the AMRTU.

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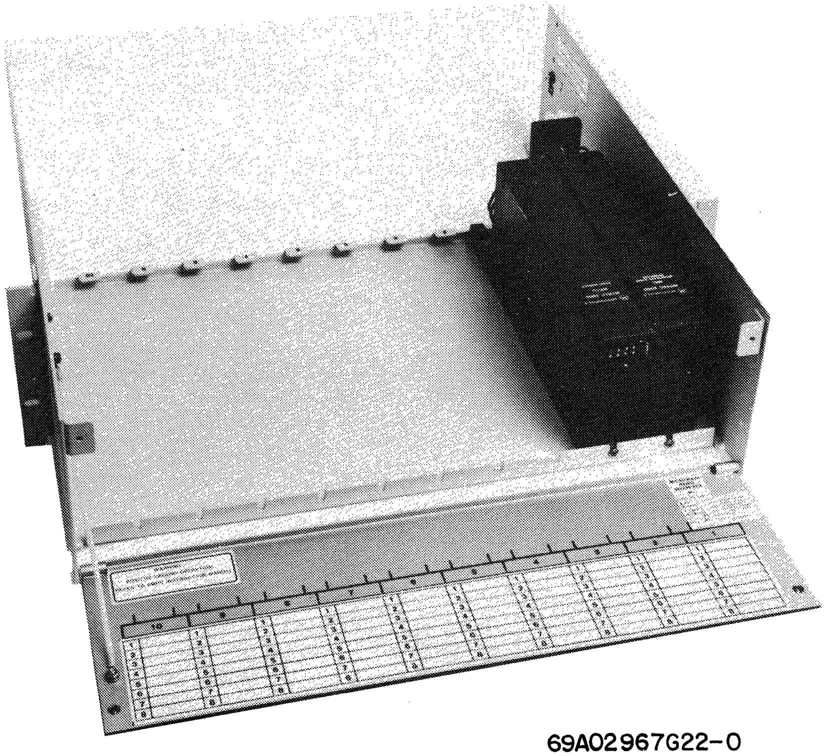

Figure 1. Front View AMRTU Basic Unit

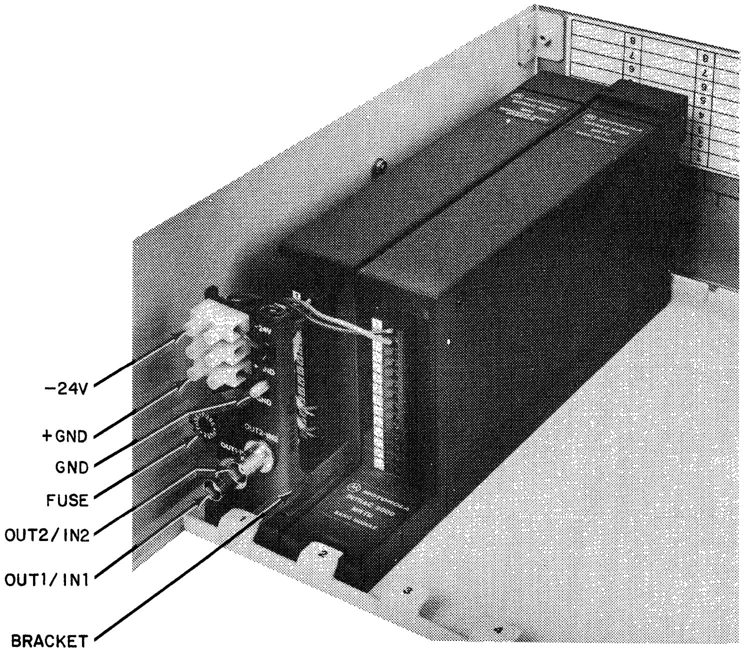

Figure 2. Rear View AMRTU Basic Unit

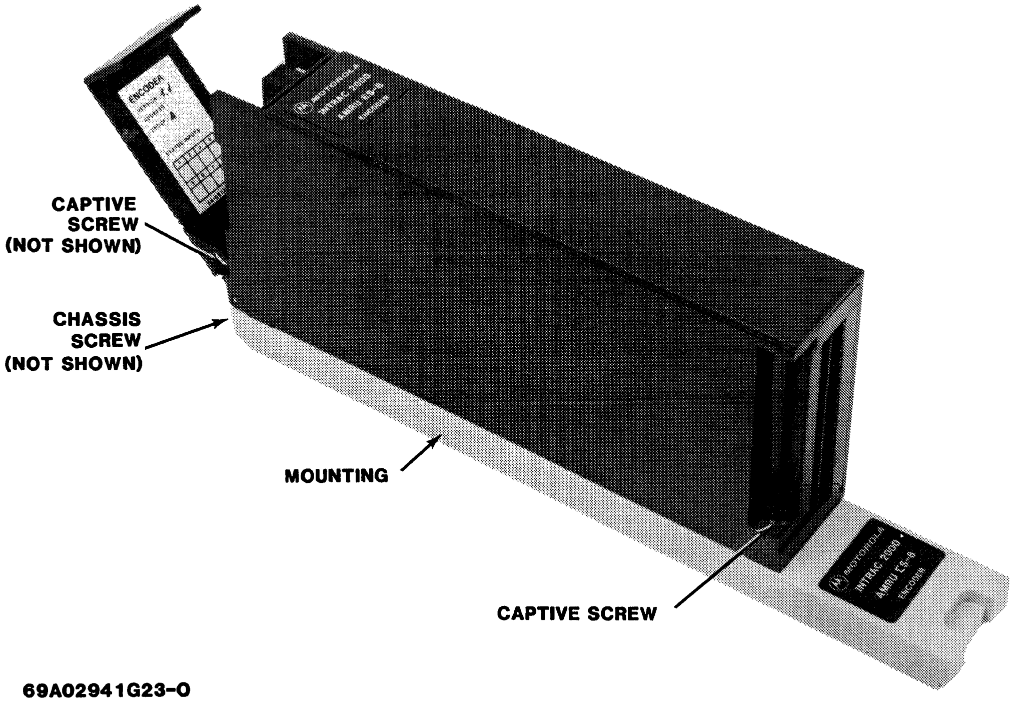

Figure 3. Module With Mounting

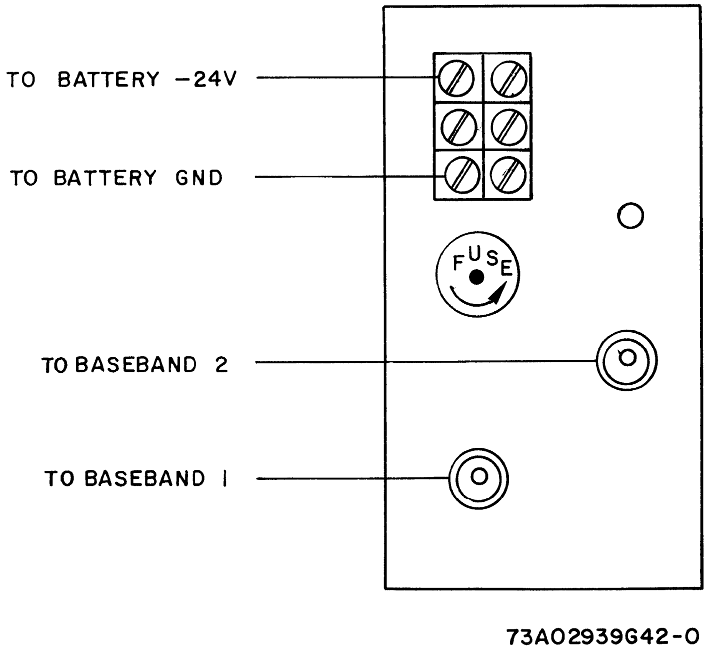

Figure 4. MRI Bracket External Wiring

Step 2. Attach the AMRTU chassis to the 19" rack using the four mounting screws provided in the rack mounting kit (FLN4563).

Step 3. Connect the interfacing cables (an AWG #18 wire is recommended) to the user connector of each module according to its specific application. For I/O function details for the user connector of each module, refer to the AMRTU terminal board user connector tables and wiring diagrams in the MRI instruction manual.

3.3 JUMPER SETTING

According to the system configuration, set jumpers of the MRI module (at the user connector) according to the MRI Jumpers Table below.

3.4 POWER CONNECTIONS

Connect the -24 V dc supply to the appropriate terminals of the MRI bracket, located behind the MRI module [GND to (+) and -24 V to (-)]. Refer to Figure 2. Rear View AMRTU Basic Unit.

4. ADJUSTMENTS

4.1 ALL MODELS

WARNING

The AMRTU operates on a positive ground supply. All low inputs of test equipment must be connected to the supply ground, and not to the AMRTU low voltage input which is -24 V.

All transmit adjustments detailed below can be performed on two levels:

a. Local transmit level adjustment - allows adjusting of the transmit signal without connection and transmission into the radio system. For local adjustments, disconnect the MRI BNC connectors (OUT1/IN1, OUT2/IN2) from the baseband.

b. Non-local transmit adjustments - all transmitted signals are transmitted into the radio system.

MRI JUMPERS TABLE

Jumper	Position*	Description
**	Default Setting	
JU1	10,11 out**	4-8 kHz baseband range
	10,11 in	8-12 kHz baseband range
JU2	9,10 out**	2-way operation (out 1/in 1 = TX/RX out 2/in 2 = TX/RX)
	9,10 in	3-way operation (out 1/in 1 = TX out 2/in 2 = RX)
JU3	5,8 out**	In 1 high input (-13 dBm to -33 dBm)
	5,8 in	In 1 low input (-33 dBm to -53 dBm)
JU4	5,6 out**	In 2 high input (-13 dBm to -33 dBm)
	5,6 in	In 2 low input (-33 dBm to -53 dBm)

* MRI jumper positions are shorted or opened on the user connector between the above-specified pins. Out = open, in = short.

Tools required:

- Selective voltmeter HP3586A or equivalent
- AC voltmeter HP400FL or equivalent
- BNC T connector
- 75 ohm 1/4 W termination resistors.
- +24 V (negative ground) power supply
- MRTU Test Cable

4.2 BASIC MODULE

4.2.1 Basic Module Adjustment

All adjustments to the basic module by a terminal should be done by operating the AMRTU using a positive power supply (negative ground) of 24 V ac at 300 mA.

Certain adjustments to the basic module require continuous transmissions, which is accomplished in one of two ways:

- pressing continuously on the Radio Test Pushbutton (on PC board).

- typing "PLL" when using a terminal.

4.2.2 FSK TX Level Adjustment

Step 1. Adjust the AMRTU Basic module FSK TX level to 120 mV rms via potentiometer R1 (clockwise = increases level, counterclockwise = decreases level).

Step 2. Disconnect the power, reassemble the AMRTU Basic module board to its housing, and attach the Basic module to the AMRTU chassis.

Step 3. Reconnect the power, and verify that the FSK TX level is 120 mV rms.

4.2.3 Baseband TX Level Adjustment

Step 1. Connect the ac voltmeter to the AMRTU BNC connector OUT1/IN1. Terminate the voltmeter with a 75 ohm resistor (total termination is 37.5 ohm) using a positive power supply terminal and send a continuous tone.

Step 2. Adjust the MRI potentiometer R47, marked OUT1, to the desired output level.

For 2-way operation repeat steps 1 and 2 with OUT2/IN2 and potentiometer R46 marked OUT2.

4.2.4 Receive Level Adjustment

Step 1. Connect the ac voltmeter to the radio and the OUT2/IN2 connector of the AMRTU, using a BNC T connector.

Step 2. Ensure that another station sends a continuous message. Record the baseband input level for adjustment of MRI jumper 4 (see MRTU Switches/ Jumpers in the MRI instruction manual). When receiving the message verify that the CM (green) LED of the MRI module is lit.

For two-way operation repeat the procedure for OUT1/IN1. Note that if the incoming message for OUT1/IN1 is from radio east, the incoming message for OUT2/IN2 will be from radio west.

Disconnect the positive power supply and connect the Microwave site's negative power supply (positive ground).

4.3 WIRELINE OPERATION (V226)

The FSK TX signal received in the MRI is generated in the Wireline Interface (WLI) module (and not in the AMRTU Basic module).

The FSK TX signal generated in the WLI module is not adjustable. Its fixed value (which is output from the WLI AGC circuit) is: 120-200 mV rms at room temperature.

The FSK TX generated in the basic module serves as an input to the WLI module; its value is adjustable.

The AMRTU and the Wireline module will both transmit a continuous test message.

The FSK TX signal generated in the WLI module is output both to the basic module and the MRI module via the External Radio Interface (XRI). Refer to the MRI instruction manual for further details.

4.3.1 Wireline Jumper Setting

The WLI is jumper set at factory for proper operation on a 600 ohm line.

4.3.2 Receive Level Adjustment

Step 1. Connect the ac or selective voltmeter to the radio and to the OUT2/IN2 connector of the AMRTU.

Step 2. Ensure that another station sends a continuous message. Record the baseband input level for adjusting MRI jumper 4. (Refer to MRI Jumper Table paragraph 3.3 in this section.) When receiving the continuous message, verify that the CM (green) LED of the MRI module is lit.

For 2-way operation repeat the procedure for OUT1/IN1. Note that if the incoming message for OUT1/IN1 issues from radio east, the incoming message for OUT2/IN2 will issue from radio west.

Step 3. Connect the ac voltmeter to the XRI module (pin 11 of the user connector). Record the MRI FSK RX out signal level.

4.3.3 FSK TX Adjustment

Step 1. Adjust the AMRTU Basic module FSK TX level to 120 mV rms via potentiometer R1, (clockwise = increases level, counterclockwise = decreases level).

Step 2. Disconnect the power, reassemble the AMRTU Basic module board to its housing, and attach the Basic module to the AMRTU chassis.

Step 3. Reconnect the power, and verify that the FSK TX level is 120 mV rms.

Verify that the FSK output level is identical to the recorded MRI FSK RX out signal level (paragraph 4.3.2, Step 3).

4.3.4 Line TX Adjustment

For proper line adjustment, FSK levels that serve as inputs to the WLI module from the two FSK sources (MRI and MRTU modules) must be equal.

Proceed as follows:

Step 1. Disconnect power from the AMRTU.

Step 2. Disconnect the WLI module from the AMRTU bus and housing.

Step 3. Open the WLI housing. Refer to WLI instruction manual for details.

Step 4. Connect the WLI module to the AMRTU bus.

Step 5. Connect the ac voltmeter to the line.

Step 6. Connect power to the AMRTU.

Step 7. Use a terminal (PLL) to make basic module transmit continuous tones.

Step 8. Adjust potentiometer R1 (line drive) in the WLI module to the desired line drive level (0 dBm over 600 ohm is the recommended value).

Step 9. Disconnect power, assemble and reinstall the WLI module to the chassis. Refer to 68P02938G05 Wireline Instruction Manual for further adjustments.

Step 10. Verify line drive level.

4.3.5 Baseband TX Level Adjustment

Repeat basic model adjustments, paragraph 4.2.1. Note that the Wireline module transmits as well.

Signals

XRI User Connector	Function
14	PTT
13	FSK TX
11	FSK RX
9	CM

5. UPGRADING A MODULAR UNIT

Modules can be attached without internal changes, and in any location desirable. However, the flat cable must be provided with the correct number of connectors (one for each module). A module mounting kit is required for each additional module.

APPENDIX I
USER CONNECTIONS

MRTU BASIC MODULE (J6)

PIN #	FUNCTION
1	RELAY K1 (N.O.)
2	RELAY K1 (COMMON)
3	STATUS INPUT #1 or RELAY K2 (N.O.)
4	STATUS INPUT #2 or RELAY K2 (COMMON)
5	STATUS INPUT #3
6	STATUS INPUT #4
7	GND/-24Vdc*
8	STATUS INPUT #5
9	STATUS INPUT #6
10	STATUS INPUT #7 or ANALOG INPUT (+)
11	STATUS INPUT #8 or ANALOG INPUT (-)
12	GND/-24Vdc*
13	+12Vdc/±24Vdc, 24Vac
14	ACPF/±24Vdc, 24Vac

* For model F6799 (microwave)

SI-8 MODULE (J1)

PIN #	FUNCTION
1	IN 9
2	IN 10
3	IN 1
4	IN 2
5	IN 3
6	IN 4
7	GND/-24V*
8	IN 5
9	IN 6
10	IN 7
11	IN 8
12	GND/-24V*
13	IN 11
14	IN 12

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AI-6 MODULE (J1)

PIN #	FUNCTION
1	AN 1+
2	AN 1-
3	AN 2+
4	AN 2-
5	AN 3+
6	AN 3-
7	AN 4+
8	AN 4-
9	AN 5+
10	AN 5-
11	AN 6+
12	AN 6-
13	NOT USED
14	GND/-24V*

* For model F6799 (microwave)

CO-8 MODULE (J1)

PIN #	FUNCTION
1	K1A NC/NO
2	K1A C
3	K2A C
4	K2A NC/NO
5	K3A C
6	K3A NC/NO
7	K4A C
8	K4A NC/NO
9	K1B C
10	K1B NC/NO
11	K2B NC/NO
12	K3B NC/NO
13	K4B NC/NO
14	K2B, K3B, K4B C

CO-4 MODULE (J1)

PIN #	FUNCTION
1	K1 C
2	K1 NO
3	K1 NC
4	K2 C
5	K2 NO
6	K2 NC
7	K3 C
8	K3 NO
9	K3 NC
10	K4 C
11	K4 NO
12	K4 NC
13	- - -
14	- - -

AO-2 MODULE (J1)

PIN #	FUNCTION
1	CH1 Vout
2	GND/-24V*
3	CH1 Iout
4	CH1 HI LIMIT
5	GND/-24V*
6	CH1 LO LIMIT
7	CH2 Vout
8	GND/-24V*
9	CH2 Iout
10	CH2 HI LIMIT
11	GND/-24V*
12	CH2 LO LIMIT
13	EXTERNAL SUPPLY
14	GND/-24V*

* For model F6799 (microwave)

WLI MODULE (J1)

PIN #	FUNCTION
1	LINE
2	Protective GND
3	LINE
4	EXT PTT IN
5	EXT CM IN
6	PTT DRY CONTACT
7	PTT DRY CONTACT
8	GND/DC MINUS/-24V*
9	EXT CM OUT/PTT DISABLE
10	FSK RX
11	EXT PTT OUT
12	FSK TX
13	AC/DC PLUS
14	AC

XRI MODULE (J1)

PIN #	FUNCTION
1	not used
2	not used
3	not used
4	not used
5	not used
6	not used
7	not used
8	not used
9	CM
10	GND/-24V*
11	FSR
12	VD (12 Vdc)
13	FST
14	PTT

* For model F6799 (microwave)

VRI MODULE (J3)

PIN #	FUNCTION
1	CHANNEL REQUEST
2	CHANNEL DISABLE
3	SPEAKER
4	AUDIO AMP SUPPLY
5	CM IN/OUT
6	GND/-24V*
7	FSR IN/OUT
8	Vd INPUT
9	FST IN/OUT
10	PTT IN/OUT

* For model F6799 (microwave)

MRI MODULE (J1)

PIN #	FUNCTION
1	OUT 1/IN 1 LOW
2	OUT 1/IN 1 HIGH
3	OUT 2/IN 2 LOW
4	OUT 2/IN 2 HIGH
5, 6	JUMPER 4 (IN 2) OUT = HIGH INPUT IN = LOW INPUT
5, 8	JUMPER 3 (IN 1) OUT = HIGH INPUT IN = LOW INPUT
9, 10	JUMPER 2 OUT = 2 WAY IN = 3 WAY
10,11	JUMPER 1 OUT = 4-8KHz IN = 8-12KHz
13	-24V
14	GND

IR-4 MODULE

J1

PIN #	FUNCTION
1	SELECT 1
2	GND 1
3	SELECT 2
4	GND 2
5	SELECT 3
6	GND 3
7	SELECT 4
8	GND 4
9	SENSE
10	ACTIVATE
11	CONTROL
12	GND
13	+12V
14	ALARM

J2

PIN #	FUNCTION
1	MOMENTARY/NOT MOMENTARY PARAMETER
2	COMMON TO PIN 1 OR 3
3	SELECT/ACTIVATE PARAMETER
4	PROTECTIVE GND
5	K1 NC
6	K1 C
7	K1 NO
8	K2 NC
9	K2 C
10	K2 NO
11	K3 NC
12	K3 C
13	K3 NO
14	K4 NC
15	K4 C
16	K4 NO

IP-8 MODULE

J1

PIN #	INTERNAL CONNECTION TO BASIC MRTU, SI-8, CI-6 MODULES
1	FREEZE IN/OUT
2	NOT USED
3	OUT 1
4	OUT 2
5	OUT 3
6	OUT 4
7	MRU GND
8	OUT 5
9	OUT 6
10	OUT 7
11	OUT 8
12	MRU GND
13,14	10-24 V ac/dc SUPPLY

J2

PIN #	USER INPUT
1	IN 1
2	PROTECTIVE GND
3	IN 2
4	PROTECTIVE GND
5	IN 3
6	PROTECTIVE GND
7	IN 4
8	PROTECTIVE GND
9	IN 5
10	PROTECTIVE GND
11	IN 6
12	PROTECTIVE GND
13	IN 7
14	PROTECTIVE GND
15	IN 8
16	PROTECTIVE GND

APPENDIX II
JUMPERS & DIP SWITCH SETTINGS

BASIC MRTU MODULE

2-Pin Jumpers

JUMPER SYMBOL	FUNCTION	POSITION: IN	POSITION: OUT
JU7	Vbat source	12Vdc (Vbat=Vd)	24Vac (Vbat from charger)
JU9	external power supply	12Vdc	24Vac/24Vdc
JU8	ac power fail indication	external (J6,14)	internal (PS charger)
JU5	inputs 7,8 (J6-10,11)	analog (4-20 mA)	status 7,8**

3-Pin Jumpers

JUMPER SYMBOL	FUNCTION	PINS 1-2	PINS 2-3
JU3*	low modulation frequency	1000 Hz	900 Hz* fixed
JU4*	high modulation frequency	1600 Hz	1500 Hz* fixed
JU1	relay K2 or status 1 (J6-3)	status 1**	relay K2 Normally Open
JU2	relay K2 or status 2 (J6-4)	status 2**	relay K2 Common
JU6	inputs 7,8 (J6-10,11)	status 7,8**	analog (4-20 mA)

* Jumpers JU3, JU4 are fixed to 900/1500 Hz and are changeable for option V108.
** Default.

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BASIC MRTU MODULE

Jumper Positions for Models and Options

Model F6014/23/53 and F6799		
JU7	JU8	JU9
OUT	OUT	OUT

Model F6509/14/23/53/56/73/74/85 and F6709/14/23/53/56/73/74/85		
JU7	JU8	JU9
IN	IN	IN

Option V051 (19" rack) and V240 (24 V dc		
JU7	JU8	JU9
OUT	OUT	OUT

Option V274 (12 V dc)		
JU7	JU8	JU9
IN	IN	IN

Basic Option

JU1	JU2	JU5	JU6	Option Description
1-2	1-2	OUT	1-2	Default - 8 status/1 control
2-3	2-3	OUT		V377 - 6 status/2 control
1-2	1-2	IN	2-3	V378 - 6 status/1 relay/1 analog

STATUS INPUT (SI-8)

SWITCH/JUMPER	POSITION	DESCRIPTION
S1-1,2,3	8 combinations	Select the second character for the port number. For S1-1,2,3=0,0,0; port=XA For S1-1,2,3=1,0,0; port=XB
S1-4	Closed Open	Second status input group disable Second status input group enable
S1-5	Closed Open	Enable COS of all status inputs Mask all status inputs (no COS)
S1-6,7,8		Select the first character for the port number. For S1-6,7,8=0,0,0; port=0X For S1-6,7,8=1,0,0; port=1X
S2		NOT USED
JU1	Closed	Watchdog enable

ANALOG INPUT (AI-2)

SWITCH/JUMPER	POSITION	DESCRIPTION
S1 rotary switch	16 positions	Select one of 16 combinations of input/output parameter settings
S2 rotary switch	8 positions	Select one of 8 combinations of Delta Limit parameter settings
S3-1,2	4 positions	Select first character of port number (0-3) For S3-1,2=ON, ON; port=3X For S3-1,2=OFF, ON; port=2X

CO-8 MODULE

SWITCH/JUMPER	POSITION	DESCRIPTION
JU1	Jumper on (NC)* Jumper on (NO)	Form of K3A (NC/NO)
JU2	Jumper on (NC)* Jumper on (NO)	Form of K2A (NC/NO)
JU3	Jumper on (NC)* Jumper on (NO)	Form of K1A (NC/NO)
JU4	Jumper on (NC)* Jumper on (NO)	Form of K4A (NC/NO)
JU5	Jumper on (NC)* Jumper on (NO)	Form of K3B (NC/NO)
JU6	Jumper on (NC)* Jumper on (NO)	Form of K2B (NC/NO)
JU7	Jumper on (NC)* Jumper on (NO)	Form of K1B (NC/NO)
JU8	Jumper on (NC)* Jumper on (NO)	Form of K4B (NC/NO)
JU9 (Port #)	Jumper on 0-7**	Select port # (i.e., 0 for port # 0 etc.) related to relays K1A-K4A
JU10 (Port #)	Jumper on 0-7**	Select port # (i.e., 0 for port # 0 etc.) related to relays K1B-K4B

* Factory default
** Default settings at factory according to module position

CO-4 MODULE

SWITCH/JUMPER	POSITION	DESCRIPTION
JU1 (Port #)	Jumper on 0-7**	Select port # (i.e., 0 for port # 0)

AO-2 MODULE

SWITCH/JUMPER	POSITION	DESCRIPTION
S1		NOT USED
S2		NOT USED
		Channel 2
JU1	c-a	5 V range
	c-b*	1 V range
		Channel 2
JU2	c-a	5 V range
	c-b*	1 V range
		Channel 1
JU3	c-a	Unipolar output 0-1 or 0-5 V
	c-b*	Bipolar output ±1 or ±5 V
		Channel 2
JU4	c-a	Unipolar output 0-1 or 0-5 V
	c-b*	Bipolar output ±1 or ±5 V
		Channel 2
JU5 (Port #)	Jumper on 0-7**	Select port # (i.e., 0 for port # 0 etc.)
		Channel 1
JU6 (Port #)	Jumper on 0-7**	Select port # (i.e., 0 for port # 0 etc.)
JU7	c-a	Power save during ac power fail
	c-b*	No such mode

* Factory default

** Default setting at factory according to module position

WLI MODULE

JUMPER	POSITION	FUNCTION
JU1-a	No jumper* Jumper	PTT output available as dry contact DC on-line option available
JU1-b,c	No jumper* Jumper	DC on-line not available DC on-line available
JU2	c-a* c-b	CM input busy-low CM input busy-high
JU3-a	No jumper Jumper*	Relay not active } For DC on-line and for Relay is active } PTT as dry contact
JU3-b	No jumper* Jumper	CM out is not a function of DC detector CM out is a function of DC detector
JU3-c	No jumper Jumper*	CM out is not a function of tone detector CM out is a function of tone detector
JU4-a,b	No jumper Jumper*	Factory use only
JU4-c	No jumper Jumper*	PTT out is not activated by tone detector PTT out is activated by tone detector
JU4-d	No jumper* Jumper	PTT out is not activated by DC detector PTT out is activated by DC detector
JU5	No jumper Jumper*	CM out is not activated by external CM input CM out is activated by external CM input
JU6	c-a* c-b	CM out busy-low CM out busy-high
JU7	c-a* c-b	LED indication on tone detector LED indication on DC detector
JU8	No jumper Jumper*	PTT out is not activated by external PTT or MRTU PTT PTT out is activated by external PTT input or MRTU PTT
JU9	No jumper* Jumper	High impedance reflected to line during reception (10 kohm) Low impedance reflected to line during reception (600 ohm)
JU10	No jumper** Jumper	For 24 V ac/dc external supply For 12 V dc external supply
JU11	c-a c-b*	J1-9 is external PTT disable J1-9 is external CM out
JU12	No jumper Jumper*	High output impedance of FSK TX (HT90 series) Low output impedance of FSK TX

*   Factory default;   ** No Factory Default

VRI MODULE

JUMPER	POSITION	FUNCTION
JU1	For shared radio	Closed for internal radio* Open for external radio
JU3	For shared radio	Closed to connect PTT to CM Open*
JU4	CM polarity	On A for radio in which CM is high when channel is busy On B for radio in which CM is low when channel is busy
JU5	For shared radio	On A for MAXAR, MAXTRAC, DARCOM radios On B for HT440, MC MICRO AMRTU and WLI option
JU6	FST level	A FST level set by R2 and R4* B FST level set by potentiometer R3

MRI MODULE

JUMPER	POSITION**	DESCRIPTION
JU1	10,11 out*	4-8 KHz baseband range
	10,11 in	8-12 KHz baseband range
JU2	9,10 out*	2-way operation (OUT1/IN1=TX/RX; OUT2/IN2=TX/RX)
	9,10 in	3-way operation (OUT1/IN1=TX; OUT2/IN2=RX)
JU3	5,8 out*	In 1 high input (-13 dBm to -33 dBm)
	5,8 in	In 1 low input (-33 dBm to -53 dBm)
JU4	5,6 out*	In 2 high input (-13 dBm to -33 dBm)
	5,6 in	In 2 low input (-33 dBm to -53 dBm)

* Default setting

** MRI jumper positions are shorted or open (on the user connector) between the specified pins. Out = OPEN in = SHORT.

IR-4 MODULE

JUMPER	CONNECTION	FUNCTION
JU1	Not connected Connected*	Module controlled by other IR-4 Module controlled by its own circuit
JU2	Not connected* Connected	Safety circuit monitors and controls relays Safety circuit monitors only
JU3	Not connected Connected*	Module controlled by other IR-4 Module controlled by its own circuit
JU4	- - -	NOT USED
JU5	Not connected* Connected	Select time-out enabled Select time-out disabled
JU6	Not connected* Connected	Single relay at a time allowed Any number of relays can be selected
JU7	Not connected*	Protective ground not connected to supply ground.
Jumper Wire on Output Connector (J2)		
	Not connected* Pin 1 to Pin 2 Pin 2 to Pin 3	30 sec select time-out only 5 sec time-out from select only (momentary) 5 sec time-out from actuate (select and actuate)

IP-8 MODULE

JUMPER	POSITION	DESCRIPTION
JU1	Connected Not connected*	J2-15 is an external freeze control input J2-15 is input 8
JU2	Connnected* Not connected	Enables freeze upon surge detection Disables freeze upon surge detection
JU3	- - -	NOT USED
JU4	- - -	NOT USED
JU5	Connected*	Factory use only
JU6	C to B*	Factory use only

* Default setting

APPENDIX III

PORT NUMBER ASSIGNMENTS

SI-8 MODULE

S1- 8 7 6	1st character	S1- 3 2 1	2nd character
0 0 0	0	0 0 0	A
0 0 1	1	0 0 1	B
0 1 0	2	0 1 0	C
0 1 1	3	0 1 1	D
1 0 0	4	1 0 0	E
1 0 1	5	1 0 1	F
1 1 0	6	1 1 0	G
1 1 1	7	1 1 1	H

1 = open, 0 = closed

SI-8 Factory Default

Module #	S1- 1,2,3,4,5,6,7,8	Port #
1	0,0,0,0,0,0,0,1	4A
2	0,1,0,0,0,0,0,1	4C
3	0,0,1,0,0,0,0,1	4E
4	0,1,1,0,0,0,0,1	4G
5	0,0,0,0,0,1,0,1	5A
6	0,1,0,0,0,1,0,1	5C
7	0,0,1,0,0,1,0,1	5E
8	0,1,1,0,0,1,0,1	5G
9	0,0,0,0,0,0,1,1	6A
10	0,1,0,0,0,0,1,1	6C
11	0,0,1,0,0,0,1,1	6E
12	0,1,1,0,0,0,1,1	6G
13	0,0,0,0,0,1,1,1	7A
14	0,1,0,0,0,1,1,1	7C
15	0,0,1,0,0,1,1,1	7E
16	0,1,1,0,0,1,1,1	7G

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AI-6 MODULE

Port number XY

Port # 1st character	S3-1	S3-2
0Y	OFF	OFF
1Y	ON	OFF
2Y	OFF	ON
3Y	ON	ON

S1 (rotary switch) selects the port number second character (see service manual).

Parameter Set #	Port Number(second character) XC	XD	XE	XF	XG	XH
0	C	C	C	C	C	C
1	C	C	C	C	IC	IC
2	C	C	C	C	DC	DC
3	V	V	V	V	V	V
4	C	C	C	C	V	V
5	C	DC	IC	V	DV	IV
6	-	C	C	C	C	IC
7	-	C	C	C	C	DC
8	-	-	C	C	C	C
9	-	-	-	C	C	C
A	-	-	-	-	C	C
B	-	-	-	-	C	IC
C	-	-	-	-	C	DC
D	-	-	-	-	-	V
E	-	-	-	-	-	C
F	User programmable (FLN4365)					

C - Current, IC - Integral of Current, DC - Derivity of Current,
V - Volt, IV - Integral of Volt, DV - Derivity of Volt.

AI-6 Factory Default

Module #	S1	S2	S3-1,2	Port #
1	0	0	ON, ON	3C,3H
2	0	0	OFF, ON	2C,2H
3	0	0	ON, OFF	1C,1H
4	0	0	OFF, OFF	0C,0H

CO-8 MODULE

For K1a, K2a, K3a, K4a

JU9	1st Port #
JU9-0	0
JU9-1	1
JU9-2	2
JU9-3	3
JU9-4	4
JU9-5	5
JU9-6	6
JU9-7	7

For K1b, K2b, K3b, K4b

JU10	2nd Port #
JU10-0	0
JU10-1	1
JU10-2	2
JU10-3	3
JU10-4	4
JU10-5	5
JU10-6	6
JU10-7	7

CO-8 Factory Default

Module #	JU9, JU10	Port #
1	0,1	0,1
2	2,3	2,3
3	4,5	4,5
4	6,7	6,7

CO-4 MODULE

JU1	PORT #
JU1-0	0
JU1-1	1
JU1-2	2
JU1-3	3
JU1-4	4
JU1-5	5
JU1-6	6
JU1-7	7

CO-4 Factory Default

Module #	Jumper on JU1
1	0
2	1
3	2
4	3
5	4
6	5
7	6
8	7

Note: If there are any CO-8 modules, then the jumper of the first CO-4 module will be placed on the next-to-last CO-8 jumper position.

ANALOG OUTPUT (AO-2)

Channel 2

JU5	Port #
JU5-0	0
JU5-1	1
JU5-2	2
JU5-3	3
JU5-4	4
JU5-5	5
JU5-6	6
JU5-7	7

Channel 1

JU6	Port #
JU6-0	0
JU6-1	1
JU6-2	2
JU6-3	3
JU6-4	4
JU6-5	5
JU6-6	6
JU6-7	7

AO-2 Factory Default

Module #	JU5,JU6	Port #
1	7,6	7,6
2	5,4	5,4
3	3,2	3,2
4	1,0	1,0

DIP switches S1 and S2 are not used.

CI-6 MODULE

The port number is assigned by two sets of DIP switches (S1, S2).

DIP Switch Position	Port #
S2-8 is closed	0B
S1-1,2 not both closed	0C
S1-3,4 not both closed	0D
S1-5,6 not both closed	0E
S1-7,8 not both closed	0F
S2-1,2 not both closed	0G
S2-3,4 not both closed	0H

CI-6 Factory Default

All DIP switches are closed; only port 0B is available.

INTRAC 2000
Modular Remote Terminal Unit
General Installation Instructions

68P02962G20-O

MOTOROLA

INTRAC 2000®

Modular Remote Terminal Unit

Service Manual

68P02957G60-O

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EPS-27734-O

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EPS-34440-B

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Communications
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INTRAC 2000®
Modular Remote Terminal Unit

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FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar types of equipment. It contains all service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date are incorporated by Instruction Manual Revisions (SMR). These SMR's are added to the manuals as the engineering changes are incorporated into the equipment.

2. MODEL AND KIT IDENTIFICATION

Motorola equipments are specifically identified by an overall model number on the nameplate. In most cases, assemblies and kits which make up the equipment also have kit model numbers stamped on them. When a production or engineering change is incorporated, the applicable schematic diagrams are updated.

3. SERVICE

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The administrative staff of this organization consists of national, area and district service managers and district representatives, all of whom are Motorola employees with the objective to improve the service to our customers.

Should you wish to purchase a service contract for your Motorola equipment, contact your Motorola Service Representative, or write to:

National Service Manager
Motorola Communications and Electronics, Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

REPLACEMENT PARTS ORDERING

ORDERING INFORMATION

When ordering replacement parts or equipment information, the complete identification number should be included. This applies to all components, kits, and chassis. If the component part number is not known, the order should include the number of the chassis or kit of which it is a part, and sufficient description of the desired component to identify it.

Crystal and channel element orders should specity the crystal or channel element type number, crystal and carrier frequency, and the model number in which the part is used.

Orders for active filters, Vibrasender and Vibrasponder resonant reeds should specify type number and frequency, should identify the owner/operator of the communications system in which these items are to be used; and should include any serial numbers stamped on the components being replaced.

MAIL ORDERS

Send written orders to the following addresses:

Replacement Parts/Test Equipment/
Crystal Service Items:
Motorola, Inc.
Communications Parts Division
Attention: Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

Federal Government Orders:

Motorola Inc.
Communications Parts Division
Attention: Order Processing
1701 McCormick Drive
Landover, MD 20785

International Orders:

Motorola Inc.
Communications Parts Division
Attention: International Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

TELEPHONE ORDERS

Replacement Parts/Test Equipment:

Call: 1-800-422-4210
1-800-826-1913 (For Federal Government Orders)

Crystal Service Items:

Call: 1-800-323-1570
1-800-445-4564 (For Illinois Residents)

TELEX/FAX ORDERS

Replacement Parts/Test Equipment/
Crystal Service Items:

Telex: 280127
FAX: 312-576-6285

Federal Government Orders:

FAX: 301-925-2473 or 301-925-2474

CUSTOMER SERVICE

Replacement Parts/Test Equipment:

Call: 1-800-537-7007

Crystals:

Call: 1-800-323-0234

Parts Identification:

Call: 312-576-7418

NATIONAL DATA SERVICES

1711 West 17th Street, Tempe, AZ 85281

Call: 602-994-6472, TWX: 910-951-1334

KIT BREAKDOWN

FRN1691A MRTU Basic Module With Power Supply Charger

FLN4627B Status Display Panel
FLN4649A Main Board
FLN4659A Label Kit
FLN4925A Modular Housing-Radio & Display
FLN4847A Power Supply Charger
FLN5720A Main Board Hardware
68P02957G60 MRTU Service Manual

FRN2001A MRTU Basic Module Without Power Supply Charger

FLN4627B Status Display Panel
FLN4649A Basic Module Main Board
FLN4659A Label Kit
FLN4792A Modular Housing
FLN5720A Main Board Hardware
68P02957G60 MRTU Service Manual

FRN2004A AMRTU Basic Unit

FLN4563A Module Mounting
FLN4627B Status Display Panel
FLN4649A Basic Module Main Board
FLN4659A Label Kit
FLN4792A Modular Housing
FLN4847A Power Supply Charger
FLN5720A Main Board Hardware
68P02957G60 MRTU Service Manual

PERFORMANCE SPECIFICATIONS

GENERAL

Input Voltage, one of the following:	11-15 Vdc, model w/o p.s. charger 22-28 Vdc, model with p.s. charger 22-28 Vac, 50/60 Hz, model with p.s. charger -22 to -28 Vdc (positive ground) with p.s. charger.
Current Consumption	52 mA typical, 271 mA max. peak
Power Bus Capability	200 mA max. to bus from 12 V VD supply (with p.s. charger) 1 A max. to bus from 12 V VD supply (w/o p.s. charger) 50 mA max. to bus from 5 V VCC supply
Operating Temperature	-30°C to + 60°C
Relative Humidity	0 to 90% w/o condensation
Weight	0.715 lbs. (350 gr) w/o p.s. charger 0.935 lbs. (425 gr) with p.s. charger
Housing	Thermoplastic
Dimensions	1.6" x 8.3" x 3.7" (h x w x d) 3.9cm x 21cm x 9.5cm (h x w x d)
I/O Connections	Screw-type terminal strip, 14 contacts

RADIO INTERFACE

PTT Output	Open collector: Darlington 200 mA, 32 V max. Leakage current: 1 uA max. On level: 1.5 V max.
PTT Indication	On-board LED
FSK Output Level	3 mV rms - 500 mV rms adjustable via potentiometer near latch door
FSK Output Distortion	2.5% max, 0.5% typical
FSK Frequency Stability	20 PPM/°C typical
FSK Amplitude Stability	4800 PPM/°C typical
Output Impedance	600 ohm

Frequency Accuracy	± 2%
FSK Input Level	30 mV to 1 V rms
Input Impedance	280k ohm
S/N Input	10 db for 99.9% throughput

USER I/O

Configurations:

Configuration	Status	Control	Analog
A	8	1	0
B	6	2	0
C	6	1	1

Configurations are selectable via jumpers and the Field Configuration Program.

Protection	Surge withstand capability according to IEEE472/ANSIC.37.90a. Capacitive discharge according to Motorola standard 12M80971A84.
COS Detection	Contact closure or opening to GND for negative ground operation. Contact closure or opening to negative supply for positive ground operation.
External Circuit	Dry contact closed < 3k ohm open > 40k ohm
Minimum Duration of Status	4 ms - 500 ms, in 4 ms increments. 4 ms default, selectable via Field Configuration Program.
Input Types	Every status can be configured as: Simple input Debounced input Counter Pulse frequency Pulse duration Run time Reclosure status. Definition by Field Configuration Program. Maximum frequency: 100 Hz, 50% duty cycle.

Analog Input	Impedance: 276 ohms min., 296 ohms max. Type: 4-20 mA, floating input. Number of inputs: 1 provided by the user 1 internal provided by battery voltage, for low battery voltage indication. Maximum common mode input 2.5 V rms
Controls	2 normally open momentary. Contact maximum rating: Voltage: 250 V Current: 2 A Power: 60 W (125 VA) Operational life: 2.5x10^{7} @ 0.5 A, 15 W 1.8x10^{6} @ 2A, 60 W

COMMUNICATION

Analog Communication	FSK pulse duration encoded
Word Format	INTRAC 2000 standard, 32 bits + frame synchronization.
Transmission Speed	600 baud
Pulse Duration Encoding	Logic 0 = 1T Logic 1 = 2T Frame sync = 3T nominal T = 1/600 = 1.67 ms.
FSK Encoding Tones	900/1500 Hz ± 2%
FSK Decoding Tones	900/1500 Hz ± 2%
Word Security	Frame synchronization, Bose-Chaudhuri cyclic code (5 bits of 31), overall parity bit.

PROCESSING UNIT

Central Processor	68HC11 including: 256 bytes RAM, 512 bytes EEPROM.
External Memory	8K static CMOS RAM 32K CMOS EPROM
Crystal Frequency	8 MHz
CPU Clock Rate (E)	2 MHz

RS-232 PORT

Supported Signals	TxD, RxD, GND only via test connector.
TxD Levels	mark: -7.3 to -7 V space: +7.5 to +8.5 V
Output Impedance	300 ohm.
RxD Levels	mark: -5 to -25V space: +5 to +25V
Input Impedance:	3k to 7k ohm.

BUS INTERFACE

Compatible with existing MRU modules (smart & serial bus).

OTHER FEATURES

On-Board PTT LED	On-board LED, visible from the latch door. Indications: 1. Startup 2. PTT 3. Data base download reception 4. PLL Decoder adjustment.
On-Board Pushbutton	Used for INTRAC 2000 test word transmission and PLL Adjust.
Test Pushbutton	TEST pushbutton, accessible from the latch door on the status display panel.
Data Base Field Configuration	Via the RS-232 port. Refer to FRN1785 Field Configuration Program.
Status Display	8 red LEDs + Test pushbutton, all located on the latch door, connection via a 10-pin flat cable. Status display for the following functions: 1. Status/Input display 2. Diagnostics 3. Trigger parameters copy to another MRTU module.

MOTOROLA INC.
Communications Sector

SAFE HANDLING OF CMOS INTEGRATED CIRCUIT DEVICES

Many of the integrated circuit devices used in communications equipment are of the CMOS (Complementary Metal Oxide Semiconductor) type. Because of their high open circuit impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping, and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective only against overvoltage in the hundreds of volts range such as are encountered in an operating system. In a system, circuit elements distribute static charges and load the CMOS circuits, decreasing the chance of damage. *However, CMOS circuits can be damaged by improper handling of the modules even in a system.*

To avoid damage to circuits, observe the following handling, shipping, and servicing precautions.

1. Prior to and while servicing a circuit module, particularly after moving within the service area, momentarily touch *both* hands to a bare metal earth grounded surface. This will discharge any static charge which may have accumulated on the person doing the servicing.

NOTE

Wearing Conductive Wrist Strap (Motorola No. RSX-4015A) will minimize static buildup during servicing.

WARNING

When wearing Conductive Wrist Strap, be careful near sources of high voltage. The good ground provided by the wrist strap will also increase the danger of lethal shock from accidentially touching high voltage sources.

2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands.

3. Normally, circuit modules can be inserted or removed with power applied to the unit. However, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram to insure there are no objections to this practice.

4. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.) because they contribute to static buildup.

5. All electrically powered test equipment should be grounded. *Apply* the *ground lead* from the test equipment to the circuit module *before* connecting the *test probe*. Similarly, *disconnect* the *test probe prior* to removing the *ground lead.*

6. If a circuit module is removed from the system, it is desirable to lay it on a conductive surface (such as a sheet of aluminum foil) which is connected to ground through 100k of resistance.

WARNING

If the aluminum foil is connected directly to ground, be cautious of possible electrical shock from contacting the foil at the same time as other electrical circuits.

7. When soldering, be sure the soldering iron is grounded.

8. Prior to connecting jumpers, replacing circuit components, or touching CMOS pins (if this becomes necessary in the replacement of an integrated circuit device), be sure to discharge any static buildup as described in procedure 1. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.

9. When replacing a CMOS integrated circuit device, leave the device in its metal rail container or con-

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ductive foam until it is to be inserted into the printed circuit module.

10. All low impedance test equipment (such as pulse generators, etc.) should be connected to CMOS device inputs after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

11. Replacement modules shipped separately from the factory will be packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material (aluminum foil may be used). NEVER USE NON-CONDUCTIVE MATERIAL for packaging these modules.

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DIAGNOSTICS, FIELD PARAMETER SETTING & MAINTENANCE

1. GENERAL

The MRTU Basic Module is based on the 68HC11 micro-computer, utilizing its enhanced processing power, EEPROM memory, A/D converters, Serial Peripheral Interface (SPI) and Serial Communication Interface (SCI). In addition to the 68HC11, the MRTU Basic Module contains a 32k EPROM and 8k RAM, external memory, two momentary relays, up to eight discrete inputs, and up to four double-ended analog inputs (one available as an option, four available as Special Products [SP]).

Figure 2. System Configuration shows the various modules that may be incorporated into an MRTU system.

The module provides hardware for FSK encoding and decoding, Push-To-Talk (PTT) and Channel Monitor (CM), with an interface for radio or wireline communication.

The module supports multi-addressing, enabling one MRTU to respond to up to four sub-addresses. MRTU-to-MRTU operation allows inputs to one MRTU to operate outputs in another MRTU. It supports internal communication within the MRTU via two serial buses; the first bus interfaces with analog input, status expansion and counter input modules and the second bus interfaces with control output, analog output, and new input protection modules.

The module supports status inputs, counters, pulse measurements, run time measurements, and reclosures. Some of these functions may be performed only on the inputs of the MRTU Basic Module itself, while others may be performed by the MRTU Basic Module on inputs from other MRTU modules. The module also supports control outputs (momentary or latched) and select-checkback-before-execute operation.

The module recognizes three types of parameters: communication parameters, I/O function parameters, which define relationships between the physical I/O and the I/O functions and parameters which may be downloaded to other modules, such as analog input and counter input, thus eliminating the need for EPROM programming and opening of the modules. The parameters may be downloaded to the MRTU Basic Module by a terminal, via an RS-232 port, and are stored in the EEPROM.

Entering the various module and option numbers automatically designates the unit parameters. Therefore, there is no need to change factory parameters, unless the standard parameters are insufficient for a specific user application.

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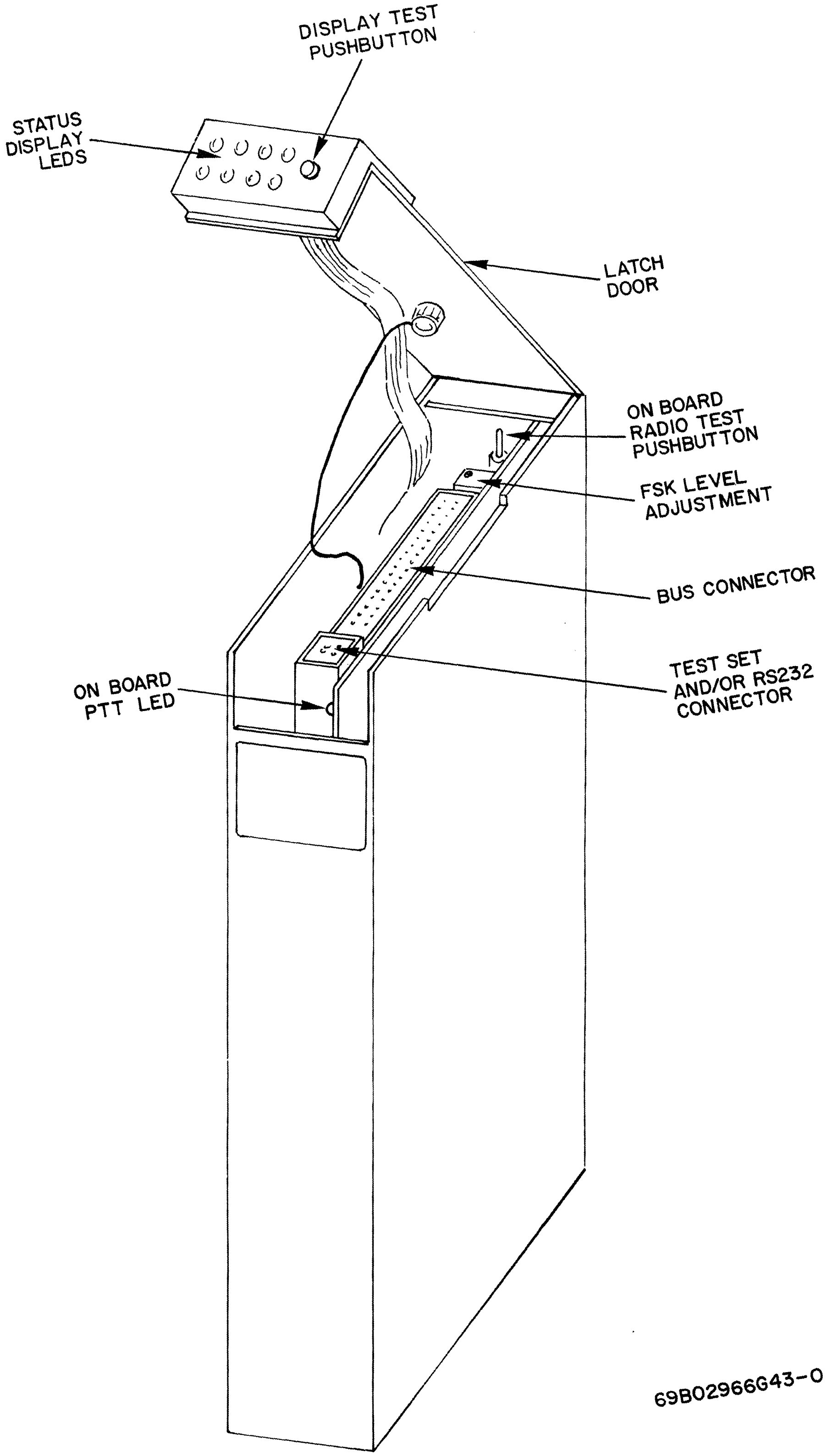
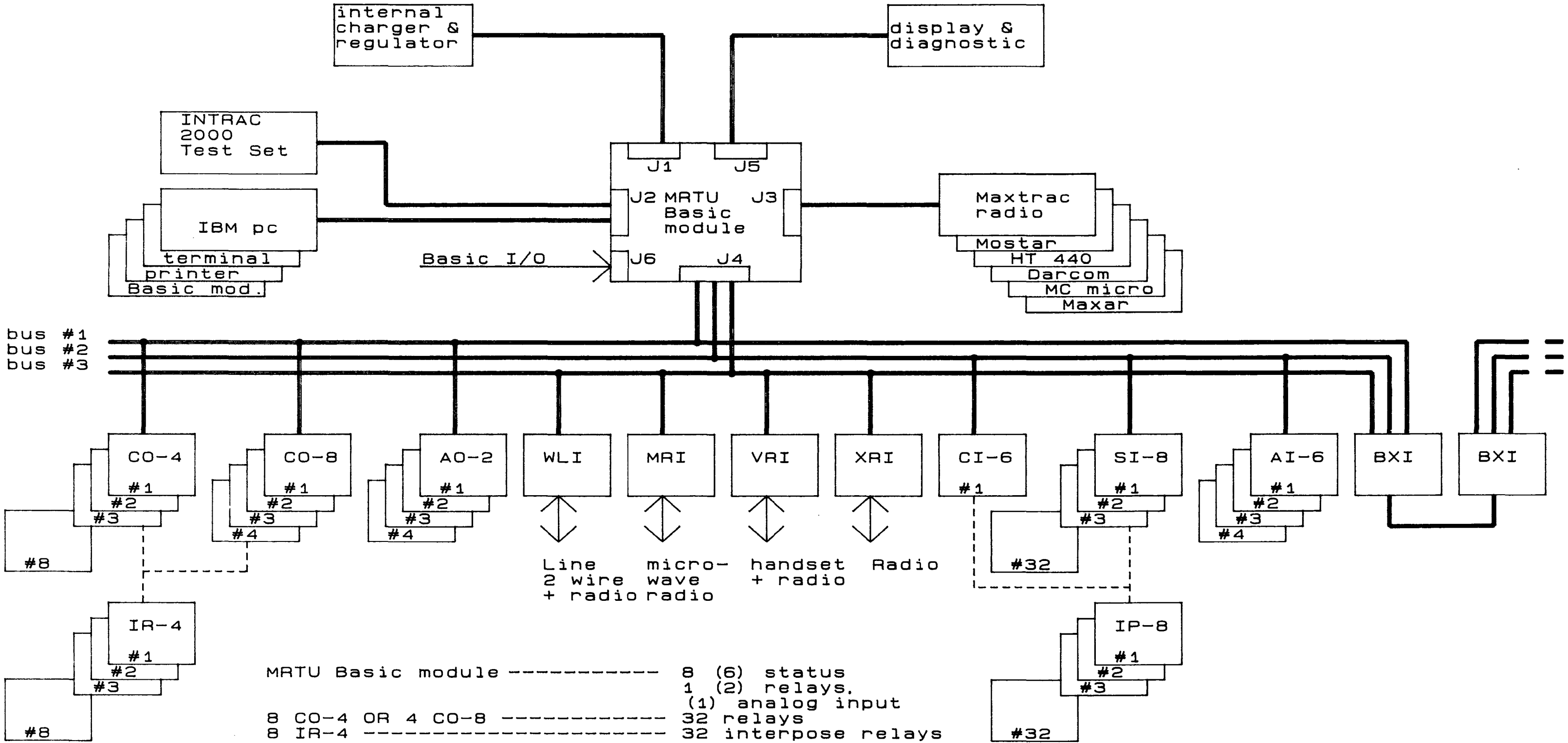


Figure 1. MRTU Basic Module



MRTU Basic module ------------ 8 (6) status
1 (2) relays,
(1) analog input
8 CO-4 OR 4 CO-8 ------------- 32 relays
8 IR-4 ----------------------- 32 interpose relays
4 AO-2 ----------------------- 8 analog outputs
32 SI-8 ---------------------- 128 status
32 IP-8 ---------------------- 128 isolated status
2 (4) AI-6 ------------------- 12 (24) analog inputs
CI-6 ------------------------- 6 counters

bus #1 - serial bus: ckr, datar, fbdata, oe1
bus #2 - smart bus: breq, busy, ck, ready, addr, data
bus #3 - radio bus: fsr, fst, cm, ptt

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Figure 2. MRTU System Configuration

The parameters are burnt into the EEPROM, they may be changed by connecting the MRTU Basic Module to an IBM PC and using the FRN1785 MRTU Field Configuration Program (FCP) Utility diskette. Some of the communication parameters, such as: CM polarity, PTT delay and INTRAC address can also be changed by connecting the module to a terminal.

NOTE

> Refer to MRTU FCP diskette for details on the various functions and parameters.

The MRTU Basic Module includes advanced maintenance and diagnostic capabilities as follows:

a. Reported internal indication to central, for limited diagnostics.
b. Eight LEDs located on the latch door of the module, for partial diagnostics.
c. RS-232 interface, for full diagnostics.

2. RS-232 MAINTENANCE DESCRIPTION

Connect an IBM PC or a suitable terminal (terminal set at 9600 bd or 300 bd, 8 bits, no parity, 1 stop bit) to the MRTU Basic module via the MRTU Test Cable (see 68P02966G84 Test Cable section).

NOTE

> The MRTU Basic Module should operate from a negative ground supply or from a 24 Vac adaptor for Diagnostic, Maintenance and Parameter Setting via an RS-232 interface.

WARNING

> For the F6799 Microwave Model, the MRTU must be disconnected from its positive ground supply and connected to a negative ground supply before connecting an IBM PC or terminal. This warning does not apply if a portable, battery-operated IBM PC, or a hand held terminal are used.

When using an IBM PC, enter the Main Menu and select the Field Support option (level 3). In the Support Menu (New Data screen 1.3), select Talk To MRTU - Terminal Mode (level 5) and press the Enter key. When using a terminal, pressing the Return key will display the main menu shown below. To activate any of the functions, the first three letters of the function name are entered (i.e., ERR, CLE, COM, etc).

MAIN MENU DESCRIPTION

ERR: display MRTU error list
CLE: clear MRTU error list
COM: modify MRTU parameters
PRI: print MRTU parameters
UPL: upload MRTU data base
SAV: save new data base into MRTU EEPROM
STA: MRTU startup
PLL: PLL tuning (on/off)
HAR: hardware tests (startup)

2.1. ERR (ERROR): Display MRTU Error List

If no errors are registered, the following message will be displayed when ERR is entered: "EMPTY ERROR LIST".

If errors are registered, one or more of the following messages will be displayed when ERR is entered:

Message	Description
LOW BATTERY DETECTED	The system has detected low battery (Vbat below 10.8 V).
AC POWER FAIL DETECTED	An ac power fail has occurred in the system (ACPF signal low).
PORT XX - DEFINITION ERROR	The programmer has assigned a specific port to a module that does not match the programmer defined module.
PORT XX - IN SMART-BUS DOES NOT ANSWER	One of the following modules has been removed or has stopped answering MRTU Basic Module interrogations: (a) AI-6 module, (b) CI-6 module, (c) SI-8 module.
PORT XX - IN SPI-BUS, DOES NOT ANSWER	One of the following modules has been removed or has stopped answering MRTU Basic Module interrogations: (a) CO-8 module, (b) AO-2 module.
SERIAL PORT ERROR	An error has been detected in the RS-232 port.
ERROR IN BCH/PCH OF INTRAC WORD	A BCH/PCH error has been detected in five out of ten consecutive, received INTRAC words.
ERRORS BUFFER DETECT	One of the buffers' holding messages is invalid.

2.2 CLE (CLEAR): Clear MRTU Error List

CLE clears the MRTU error list from the EEPROM.

2.3 COM: Modify MRTU Basic Module Parameters

(Refer to the MRTU Operation diskette.)

The MRTU Basic Module can be programmed in the field via an RS-232 port, to enable field setting of various parameters.

When COM is entered, 27 field programmable parameters will be displayed (one by one), thus enabling field alteration of parameter settings.

FIELD PROGRAMMABLE PARAMETERS

NOTE

1. Items in parenthesis indicate parameter range.
2. Items in brackets are current values stored in RAM.

1. SYSTEM ADDRESS (0-3)[0] :
2. TRUNKING RADIO SYSTEM [N] :
3. CENTRAL/REMOTE BASE ADDRESS (0-511)[0] :
4. # OF CENTRAL/REMOTE SUB-ADDR (1-4)[1] :
5. REMOTE/REMOTE BASE ADDRESS (0-511)[0] :
6. # OF REMOTE/REMOTE SUB-ADDR (1-4)[1] :
7. RTR SUB-ADDRESS 0 ENABLE GROUPS [ ] :
8. RTR SUB-ADDRESS 1 ENABLE GROUPS [ ] :
9. RTR SUB-ADDRESS 2 ENABLE GROUPS [ ] :
10. RTR SUB-ADDRESS 3 ENABLE GROUPS [ ] :
11. PTT DELAY (5 -6300)[100 MS] :
12. # OF TRANSMISSIONS PER COS (1-16)[4] :
13. TRANSMISSION INTERVAL (10-80)[20 SEC] :
14. TWO SECONDS LIMIT ON TRANSMISSION [N] :
15. WAIT AFTER 2 SECONDS LIMIT (1-60)[60 SEC]:
16. # OF WORD REPETITIONS PER BURST (1-8)[4] :
17. CM OVERRIDE (NO=0, OR 1-120)[60 SEC] :
18. CHANNEL MONITOR (CM) POLARITY [L] :
19. RECEPTION CONDITIONED BY BUSY CHANNEL [N] :
20. RADIO MODULATOR ALWAYS ENABLED [N] :
21. PERIODIC TIMER (0-576)[0 * 5 MIN] :
22. ENABLE SETCALL MASK [N] :
23. ENABLE SETCALL FREEZE [N] :
24. ENABLE SETCALL CONTROL [Y] :
25. ENABLE SETCALL ACKNOWLEDGE [Y] :
26. ENABLE SETCALL INTERROGATION [N] :
27. STOP TRANSMISSION ON LOW BATTERY [N] :

* The microprocessor multiplies the number entered by 5.

Pressing the Return key will advance the screen to the next parameter. Entering a value and pressing the Return key will enter the new value (store it in RAM) and advance the screen to the next parameter. To change a parameter, perform the following:

Step 1. Enter the new value.

Step 2. Press the Return key to record the new value into the RAM.

Step 3. Press the Ctrl key and letter C simultaneously to exit the list and display the main menu on the screen.

Step 4. To verify that the new value has been entered, enter COM and press the Return key; the new values will be displayed, one-by-one with each press of the Return key.

Step 5. Once the new values have been verified, enter SAV and press the Return key to save the new value in the EEPROM.

NOTE

It is advisable to use the SAV function only when all parameter modifications have been verified. This function saves the new parameters in the EEPROM and implements them.

2.4 PRI (PRINT): Print MRTU Basic Module Parameters

Outputs the 27 parameters stored in the RAM as an ASCII string, via an RS-232 port, if the module is connected to a terminal screen or a printer.

2.5 UPL (UPLOAD): Upload Existing Data Base

The MRTU Basic Module transmits its own data base (stored in the EEPROM) as an ASCII string via the RS-232 port onto the terminal screen, with the header DOWNLOAD.

2.6 SAV (SAVE): Save Changes From Last Modify

The SAV command stores (in the EEPROM) the changes that have been made using the COM function. Once the SAV function is entered (after about 10 sec.), "STARTUP MRTU Version VX.X" is displayed on the screen; this is the verification that the SAV command has been effected. If no new parameters have been entered, entering SAV will not cause any reaction by the system.

2.7 STA (STARTUP): Startup MRTU Basic Module

The STA function starts the MRTU Basic Module. The following message is displayed on the screen: STARTUP MRTU Version VX.X.

2.8 PLL: PLL Tuning (On/Off)

The PLL function enables adjustment of the PLL demodulator when connecting FST to FSR.

The MRTU Basic Module transmits "zeros" via the modulator for 5 minutes, thus resulting in a square wave at U5. The LED on the MRTU Basic Module will light or blink according to the PLL demodulator tuning process. If the LED does not light-up or blink, the PLL is not tuned; when the LED lights constantly, the PLL is tuned.

CAUTION

The MRTU Basic Module activates PTT during PLL adjustment.

In order to adjust the PLL perform the following:

Step 1. Short the signals FSR and FST; pins 12, 26 on J4 bus connector, or pins 11, 6 on J3 radio connector, or pins 5, 2 on J2 test connector.

Step 2. Type PLL and press the Return key.

Step 3. Adjust potentiometer R27 until the on-board LED lights constantly.

Step 4. Disconnect the short.

Step 5. Type PLL again to exit.

Pressing the MRTU Basic Module on-board pushbutton for at least 3 seconds will also enable the PLL function; but only as long as the pushbutton is being pressed. Releasing the pushbutton terminates the PLL tuning and sends a test message.

2.9 HAR: Hardware Tests (Startup)

The HAR function enables direct hardware diagnostics.

CAUTION

Hardware diagnostics are to be performed under laboratory conditions only.

3. RS-232 DIAGNOSTICS DESCRIPTION

The hardware diagnostic functions are part of the MRTU Basic Module's software; they have been introduced into the final product for high level diagnostics and maintenance purposes. The functions were originally introduced for R&D purposes and are based on the internal operation of the module; therefore, the form in which the data is entered may seem complicated and not user friendly at times.

The hardware test program checks operation of the MRTU Basic Module hardware from a terminal via an RS-232 interface, and the MRTU test cable.

The operations available to the user, via menus and the expected input data format, are described below.

NOTE

All inputs must be entered in capital letters.

3.1 OPERATIONS MAIN MENU

Screen Display:

```
1 : FSK Decoder
2 : FSK Encoder
3 : SP-8 Input
4 : Local Input
5 : AI-6, SI-8, CI-6 Input
6 : AO-2, CO-4, CO-8 Output
7 : Local Output
8 : Display LEDs
9 : CPU Ports
E : Exit Hardware Diagnostics
```

The main menu will allow the user to select from nine categories of hardware tests. Each menu item is listed below with the hardware function it tests.

Item	Hardware Function
1. FSK Decoder	- FSK demodulator
2. FSK Encoder	- FSK modulator
3. SP-8 Input	- SP-8 module connected to SPI bus (for future use)

4. Local Input	- MRTU Basic Module status inputs (8) - MRTU Basic Module 8-bit analog inputs (4) - battery voltage measurement (Vbat)
5. AI-6, SI-8, CI-6 Input	- These modules are controlled through the Smart bus
6. AO-2, CO-4, CO-8 Output	- These modules are controlled through the SPI port
7. Local Output	- MRTU Basic Module (local) relays
8. Display LEDs	- on-board LED - status display LEDs
9. CPU Ports	- read port A - read port G - PTT set/clear - modulator on/off - Pulse Duration Output high/low

LEGEND:

SPI - Serial Peripheral Interface of the 68HC11 CPU.
Smart Bus - Interface between the MRTU Basic Module and AI-6, CI-6, SI-8 modules; it includes the following signals: READY, DATA, BUSY, CK, ADDR, BREQ.

In addition, the hardware test program will automatically provide three tests that do not require menu selection. When any of these conditions are detected, one or more of the following messages appear automatically on the screen:

1. AC power fail detected; ACPF line low detect
2. AC power recovered
3. Display pushbutton pressed; DTST line high detect
4. Radio pushbutton pressed; RTST line low detect.

NOTE

Exiting the Hardware Diagnostics menu will cause STA (Startup).

After the user selects one of the nine tests from the main menu, a menu of options available for the selected operation is presented. After each selection of a menu item, the user is prompted for any additional information required, such as: port number, data, counter values, etc. ALL USER INPUT DATA MUST BE ENTERED AS HEXADECIMAL VALUES.

3.2 MRTU WORD FORMAT

NOTE

In order to take advantage of the capabilities described below the user must be familiar with the MRTU word format.

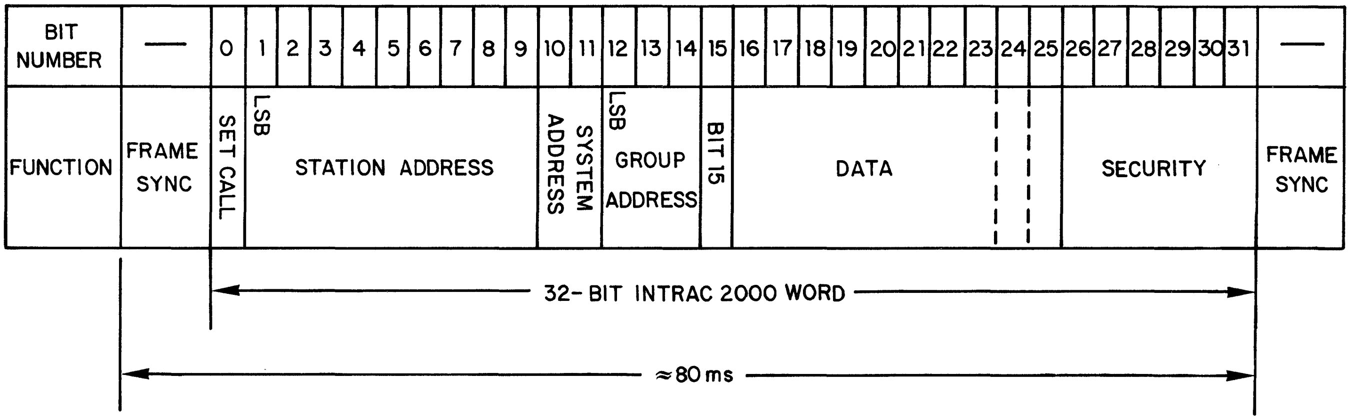

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Figure 3. 32-Bit INTRAC 2000 Word

INTRAC 2000 Word Representation

EXAMPLE I

The following example translates an INTRAC word as displayed on the screen to its binary code and shows its location as used for hardware functions in the FSK Encoder, FSK Decoder (refer to Appendix I, Decimal - Binary - Hexadecimal Conversion Table).

Every byte is sent in reverse order, therefore, it must be switched.

Hexadecimal word on screen (displayed or entered):

	0 1	8 0	8 0	1 E
Binary Code:	0000 0001	1000 0000	1000 0000	0001 1110
Switched Code: (MSB <--> LSB)	1000 0000	0000 0001	0000 0001	0111 1000

10000000000000010000000101111000

Character	Bit Number	Description
First character	0	No setcall
Next 9 characters	1 - 9	Remote Address 0
Next 2 characters	10 - 11	System Address 0
Next 3 characters	12 - 14	Group A
Next character	15	From Central
Next 8 characters	16 - 23	Data
Next 2 characters	24, 25	Execute
Next 6 characters	26 - 31	BCH, PCH Error Bits.

3.3 MAIN MENU

3.3.1 FSK Decoder

Screen Display:

1 : Continuous Display
2 : Display Last Word Received
3 : Clear Receive Counter
4 : Display Receive Counter & Expected Word
5 : Set Expected Word

3.3.1.1 Continuous Display

Displays each received INTRAC word on the screen. An INTRAC word consists of; frame synchronization followed by 32 consecutive bits (refer to Example I. for INTRAC word representation). BCH/PCH is NOT checked.

3.3.1.2 Display Last Word Received

Displays last INTRAC word received (refer to Example I. for INTRAC word representation).

3.3.1.3 Clear Receive Counter

Clears the counter of received words. The receive counter counts all valid words received until cleared.

3.3.1.4 Display Receive Counter & Expected Word

Displays the 16 bit counter of received words. This counter is incremented each time a valid INTRAC word is received. May be used in conjunction with the "FSK Encoder" of another module.

3.3.1.5 Set Expected Word

Defines the expected word to be received. The user enters 8 hexadecimal digits representing the 32-bit INTRAC word. If BCH/PCH bits are zero, the BCH/PCH will be calculated automatically (refer to Example I for INTRAC word representation).

3.3.2 FSK Encoder

Screen display:

1 : Set Repetitions Counter
2 : Send INTRAC word

3.3.2.1 Set Repetitions Counter

Sets the number of times to transmit (in hexadecimal) the requested INTRAC word; default 1; maximum 255.

3.3.2.2 Send INTRAC Word

Causes the user input word to be transmitted according to the number of repetitions defined. The user enters 8 hexadecimal digits representing the 32-bit INTRAC word. If BCH/PCH bits are zero, the BCH/PCH will be calculated automatically (refer to Example I for INTRAC word representation).

3.3.3 SP-8 Input

NOTE

Connection of the SP-8 module to the SPI bus is an option that is not available at this time.

Screen Display:

1 : Read SP-8 Data
2 : Existing SP-8 Ports

3.3.3.1 Read SP-8 Data Connected To The SPI Port

Displays the received data for a given input port . The user enters the desired port number as two hexadecimal digits (0A - 7H). The data is displayed as an 8-bit hexadecimal value. If the port does not exist, a value of FF is displayed.

3.3.3.2 Existing SP-8 Ports

Checks all existing SP-8 input port numbers (0A - 7H) and displays a list of existing ports.

3.3.3.3 SP-8 Port

The character on the left represents the position of jumper JU3 (pins 0 to 7), the character on the right represents the position of jumper JU4 (pins A to H) of the SP-8 module.

EXAMPLE II

1 : Read SP-8 Data
2 : Existing SP-8 Ports

Enter: 2

Response:
The following SPI input ports exist:
6A (JU3 = 6, JU4 = A).

If no value is displayed no port exists.

3.3.4 Local Input

Screen Display:

```
Local Status:     HH         MSB is  Status 1
Local Analog 1:   HH         IN8-IN7
Local Analog 2:   HH         IN6-IN5
Local Analog 3:   HH         IN4-IN3
Local Analog 4:   HH         IN2-IN1
Battery Voltage:  HH
```

The Local Input displays the 8 status inputs, 4 analog inputs and the battery voltage.

'HH' represents two hexadecimal characters. It displays the current value for local inputs. This data includes status data, four analog values (floating), and battery voltage input value.

EXAMPLE III

Enter: 4

Response:

Local Status : 40 (0100 0000) Status 2 closed, Statuses 1,3,4,5,6,7,8 open

Local Analog 1 : 00
Local Analog 2 : 00
Local Analog 3 : 00
Local Analog 4 : 03
Battery Voltage: F0

Vbat = Hex value multiplied by 0.062 Volts

Vbat = F0 Hex value X 0.062 = 14.88 Volts

Local analog values are meaningful only for Analog 1 (IN8-IN7), jumpered for 4-20 mA analog (JU5 IN, JU6 2-3).

The analog values are referenced to Vref = 2.5V.

The analog value in volts is:

$$\frac{HH \times 2.5}{FF} \quad \text{for Hex. or,} \quad \frac{DD \times 2.5}{255} \quad \text{for decimal}$$

DD = decimal value of HH Hex value. See Appendix I for conversion values.

3.3.5 AI-6, SI-8, CI-6 Input

Screen Display

Enter Port Number (02):
Smart Bus Response: HH HH

Interrogates the requested input port and displays the data received. The user enters the desired port number as two hex digits (0A - 7H). The data is displayed as 4 hexadecimal digits according to the following format:

3.3.5.1 AI-6

ANALOG/COUNTER DATA PORT (AI-6), (CI-6)

msb							lsb	
0	COS	X*	0	0	0	A9	A8	COS bit set if module reports COS
A7	A6	A5	A4	A3	A2	A1	A0	A9-A0 analog/counter data bits

X* - If X=1, then the second byte contains the error code, as follows:

			E5	E4	E3	E2	E1

E1 - module does not answer
E2 - timeout exceeded
E3 - wrong port number answered
E4 - illegal value in bit 8
E5 - parity error

The ports of the AI-6 module are defined by DIP switches S3 and S1. (See Table 1 which describes preprogrammed combinations of input/output parameter sets.)

The first character represents the AI-6 module address (0 - 3) as defined by DIP switches S3-1 and S3-2 on the AI-6 module.

First Character	S3-1	S3-2	Factory Default
0	OFF	OFF	FOURTH MODULE
1	ON	OFF	THIRD MODULE
2	OFF	ON	SECOND MODULE
3	ON	ON	FIRST MODULE

The second character represents one out of six inputs of the AI-6 module (C - H) according to Table 1.

EXAMPLE IV

(A) When S3-1 is closed, S3-2 is closed and the rotary switch S1 is in position zero six analogs are enabled with the following ports:

AN1 Port: 3C
AN2 Port: 3D
AN3 Port: 3E
AN4 Port: 3F
AN5 Port: 3G
AN6 Port: 3H

(B) When S3-1 is open, S3-2 is closed and the rotary switch is in position B, two analogs are enabled with the following ports:

AN1 Port: 2G
AN2 Port: 2H

3.3.5.2 SI-8

STATUS DATA PORT (SI-8)

```
  msb                                   lsb
 ----------------------------------------
 | 1  |COS | X* | 0  | 0  | 0  | 0  | 0  |      COS bit set if module reports COS
 ----------------------------------------
 ----------------------------------------
 | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 |      S1-S8 status data
 ----------------------------------------
```

X* - If X=1, then the second byte contains the error code, as follows:

```
 ----------------------------------------
 |    |    |    | E5 | E4 | E3 | E2 | E1 |
 ----------------------------------------
```

E1 - module does not answer
E2 - timeout exceeded
E3 - wrong port number answered
E4 - illegal value in bit 8
E5 - parity error

Table 1. Preprogrammed Combinations of Input/Output Parameter Sets for AI-6 Module with MRTU Basic Module via Rotary Switch S1.

AI-6 #	1	2	3	4	5	6
S1 \ Port*	C	D	E	F	G	H
0	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA
1	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Integral 4-20 mA	Integral 4-20 mA
2	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Deriv 4-20 mA	Deriv 4-20 mA
3	Raw ±1V	Raw ±1V	Raw ±1V	Raw ±1V	Raw ±1V	Raw ±1V
4	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw ±1V	Raw ±1V
5	Raw 4-20 mA	Deriv 4-20 mA	Integral 4-20 mA	Raw ±1V	Deriv ±1V	Integral ±1V
6	Not Exist	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Integral 4-20 mA
7	Not Exist	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Deriv 4-20 mA
8	Not Exist	Not Exist	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA
9	Not Exist	Not Exist	Not Exist	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA
A	Not Exist	Not Exist	Not Exist	Not Exist	Raw 4-20 mA	Raw 4-20 mA
B	Not Exist	Not Exist	Not Exist	Not Exist	Raw 4-20 mA	Integral 4-20 mA
C	Not Exist	Not Exist	Not Exist	Not Exist	Raw 4-20 mA	Deriv 4-20 mA
D	Not Exist	Not Exist	Not Exist	Not Exist	Not Exist	Raw ±1V
E	Not Exist	Not Exist	Not Exist	Not Exist	Not Exist	Raw 4-20 mA
F	User Combination Programming Parameters					

* Port number second character

The software version on the SI-8 printed circuit board has been updated to V1.1 to support MRTU multi-addressing. DIP switches S1-6, S1-7 and S1-8 are now in use to support port assignment. The port number range is 0B-7H and is represented by two characters (refer to Tables 2 and 3 below). The value of the characters is set by the SI-8 module DIP switches S1-1, 2, 3, 6, 7 and 8 as follows:

NOTE

> Any DIP switch changes in the SI-8 module must be followed by pressing the on board SI-8 Test Switch.

Table 2.

S1 8 7 6	1st character
0 0 0	0
0 0 1	1
0 1 0	2
0 1 1	3
1 0 0	4
1 0 1	5
1 1 0	6
1 1 1	7

Table 3.

S1 3 2 1	2nd character
0 0 0	A
0 0 1	B
0 1 0	C
0 1 1	D
1 0 0	E
1 0 1	F
1 1 0	G
1 1 1	H

Table 4. SI-8 Port Assignment

DIP Switch S1

8,7,6,	5,4,	3,2,1	Port #	Factory Set Default Port
0 0 0	0 0	0 0 0	NONE	
0 0 0	0 0	0 0 1	0 B	
0 0 0	0 0	0 1 0	0 C	
0 0 0	0 0	0 1 1	0 D	
0 0 0	0 0	1 0 0	0 E	
0 0 0	0 0	1 0 1	0 F	
0 0 0	0 0	1 1 0	0 G	
0 0 0	0 0	1 1 1	0 H	
0 0 1	0 0	0 0 0	1 A	
0 0 1	0 0	0 0 1	1 B	
0 0 1	0 0	0 1 0	1 C	
0 0 1	0 0	0 1 1	1 D	
0 0 1	0 0	1 0 0	1 E	
0 0 1	0 0	1 0 1	1 F	
0 0 1	0 0	1 1 0	1 G	
0 0 1	0 0	1 1 1	1 H	
0 1 0	0 0	0 0 0	2 A	
0 1 0	0 0	0 0 1	2 B	
0 1 0	0 0	0 1 0	2 C	
0 1 0	0 0	0 1 1	2 D	
0 1 0	0 0	1 0 0	2 E	
0 1 0	0 0	1 0 1	2 F	
0 1 0	0 0	1 1 0	2 G	
0 1 0	0 0	1 1 1	2 H	
0 1 1	0 0	0 0 0	3 A	

(continued) Table 4. SI-8 Port Assignment

DIP Switch S1

8,7,6,	5,4,	3,2,1	Port #	Factory Set Default Port
0 1 1	0 0	0 0 1	3 B	
0 1 1	0 0	0 1 0	3 C	
0 1 1	0 0	0 1 1	3 D	
0 1 1	0 0	1 0 0	3 E	
0 1 1	0 0	1 0 1	3 F	
0 1 1	0 0	1 1 0	3 G	
0 1 1	0 0	1 1 1	3 H	
1 0 0	0 0	0 0 0	4 A	1st module default port, factory set.
1 0 0	0 0	0 0 1	4 B	
1 0 0	0 0	0 1 0	4 C	2nd module default port, factory set.
1 0 0	0 0	0 1 1	4 D	
1 0 0	0 0	1 0 0	4 E	3rd module default port, factory set.
1 0 0	0 0	1 0 1	4 F	
1 0 0	0 0	1 1 0	4 G	4th module default port, factory set.
1 0 0	0 0	1 1 1	4 H	
1 0 1	0 0	0 0 0	5 A	5th module default port, factory set.
1 0 1	0 0	0 0 1	5 B	
1 0 1	0 0	0 1 0	5 C	6th module default port, factory set.
1 0 1	0 0	0 1 1	5 D	
1 0 1	0 0	1 0 0	5 E	7th module default port, factory set.
1 0 1	0 0	1 0 1	5 F	
1 0 1	0 0	1 1 0	5 G	8th module default port, factory set.
1 0 1	0 0	1 1 1	5 H	
1 1 0	0 0	0 0 0	6 A	9th module default port, factory set.
1 1 0	0 0	0 0 1	6 B	
1 1 0	0 0	0 1 0	6 C	10th module default port, factory set.
1 1 0	0 0	0 1 1	6 D	
1 1 0	0 0	1 0 0	6 E	11th module default port, factory set.
1 1 0	0 0	1 0 1	6 F	
1 1 0	0 0	1 1 0	6 G	12th module default port, factory set.
1 1 0	0 0	1 1 1	6 H	
1 1 1	0 0	0 0 0	7 A	13th module default port, factory set.
1 1 1	0 0	0 0 1	7 B	
1 1 1	0 0	0 1 0	7 C	14th module default port, factory set.
1 1 1	0 0	0 1 1	7 D	
1 1 1	0 0	1 0 0	7 E	15th module default port, factory set.
1 1 1	0 0	1 0 1	7 F	
1 1 1	0 0	1 1 0	7 G	16th module default port, factory set.
1 1 1	0 0	1 1 1	7 H	

1 = open
0 = close

DIP switch S1-4 sets the SI-8 module to dual port (12 status points in two ports); eight in the first port and four in the second port. The second port is enabled by switch S1-4 "1" (open) and its value is the consecutive value, for example:

Basic Port	Consecutive Port
0C	0D
1D	1E
2F	2G
3B	3C
7E	7F

Note the following exceptions:

Basic Port	Consecutive Port
0H	0B
1H	1A
2H	2A
3H	3A
4H	4A
5H	5A
6H	6A
7H	7A

The four additional status inputs are not factory default settings. To enable the four additional status inputs do as follows:

Step 1. Set S1-4 to "1" open.

Step 2. Define the four status inputs as an additional SI-8 module via the FRN1785 Field Configuration Program. (It is not necessary to change the other ports as they are factory set in steps of 2.)

S1-5 enables Mask (S1-5 = open); its default setting is S1-5 = close Unmask.

EXAMPLE V

(A)
Screen Display:

Enter Port Number (02): 4B
Smart Bus Response: 80 14

4B (see Table 2): S1-8,7,6 = 1,0,0
(see Table 3): S1-3,2,1 = 0,0,1

80 = 1000 0000 no COS [from STATUS DATA PORT (SI-8)]

14 = 0001 0100 Status 1, 2, 3, 5, 7, 8 = Open
Status 4, 6 = Closed

(B)
Screen Display:

Enter Port Number (02): 1C
Smart Bus Response: 20 01

0010 0000,	0000 0001
error code	module does not answer

3.3.5.3 CI-6

Port 0B status reading for the CI-6 module is identical to that of the SI-8 module.

Port analog reading of 0C to 0H is identical to the analog value reading format of the expansion AI-6 module.

3.3.6 SPI OUTPUT (AO-2, CO-4, CO-8 Modules)

Screen Display:

1 : Send Control/Analog Data
2 : Existing Output Ports

3.3.6.1 Send Control/Analog Data

Sends the requested output operation to an analog output port, or to a control output port connected to the SPI port. The user enters 24 bits of data as 6 hexadecimal digits. When a relay output port is selected, an 8-bit hexadecimal back-indication is displayed. The data formats are shown below.

ANALOG OUTPUT PORT DATA REPRESENTATION

```
 msb                             lsb   A0-A9 represent 10-bit analog unipolar value.
 -------------------------------       A9 is msb
|0  |0  |0  |0  |0  |0  |A0 |A1 |
 -------------------------------
 -------------------------------
|A2 |A3 |A4 |A5 |A6 |A7 |A8 |A9 |
 -------------------------------        P0 = "1" selects port 0
 -------------------------------        P1 = "1" selects port 1, etc.
|P0 |P1 |P2 |P3 |P4 |P5 |P6 |P7 |       Only one port may be selected at a time and all
 -------------------------------        other bits must be ="0" (walking one format).
```

EXAMPLE VI

Analog Value [mA]	10-Bit Analog Value msb lsb A9,A8,A7,A6,A5,A4,A3,A2,A1,A0 msb lsb	Output Data for Port 7 Enter
3.8	0 0, 0 0 0 0, 0 0 0 0	000001
20.18	1 1, 1 1 1 1, 1 1 1 1	03FF01
20	1 1, 1 1 1 1, 0 1 0 0	00BF01
4	0 0, 0 0 0 0, 1 1 0 0	00C001
12	1 0, 0 0 0 0, 0 0 0 0	000101

ANALOG OUTPUT PORT BACK-INDICATION

```
 ---------------          ---------------
| X | X | X | X|         | 0 | 1 | 0 | 0 |
 ---------------          ---------------
                         Analog Output ID
```

The first character represents DIP switch S1 or S2, (on the AO-2 board); these DIP switches are not in use with the MRTU.

NOTE

The analog output port ID is 4. When no port exists the ID is 0.

CONTROL OUTPUT PORT

```
  msb                           lsb
  -------------------------------
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
  -------------------------------     K1R,K1S = "10" - resets relay K1
  -------------------------------     K1R,K1S = "01" - sets relay K1
|K1R|K1S|K2R|K2S|K3R|K3S|K4R|K4S|     K1R,K1S = "00" - no change in K1
  -------------------------------     K1R,K1S = "11" - illegal operation
  -------------------------------
|P0 |P1 |P2 |P3 |P4 |P5 |P6 |P7 |     P0-P7 walking one format. Only one bit may
 --------------------------------     be selected as 1; P0 = 1 selects port 0,
                                      P1 = 1 selects port 1 etc.
```

CONTROL OUTPUT PORT BACK-INDICATION

```
  ---------------          ---------------
|K4B|K3B|K2B|K1B|         |0 | 1 | 1 | 0 |
  ---------------          ---------------
                          Control Output ID
```

Example

Back Indication: K1, K3 Set

```
  ---------------      ---------------
| 0 | 1 | 0 | 1 |     | 0 | 1 | 1 | 0 |
  ---------------      ---------------
 Relays status        Control output ID
```

Example

To set relay K1 of Port 5:

0: Menu
1: Send Control/Analog Data
2: Existing Output Ports

Enter 1
Send control data to port 5 (bit P5 set)
Enter output data (06): 804004

```
1000 0000 0100 0000 0000 0100
  8    0    4    0    0    4
```

NOTE
The control output port ID is 6.
The analog output port ID is 4.
When no port exists the ID is 0.

3.3.6.2 Existing Output Ports

Checks all possible SPI output port numbers (0-7) and displays list of existing ports with module type (control, analog) and back indication.

EXAMPLE VII

Enter 2:

Port #	Back Indication	Description
Port 00	F6	All relays set (F) control output port (6)
Port 01	F0	Port does not exist (0)
Port 02	F0	Port does not exist (0)
Port 03	F0	Port does not exist (0)
Port 04	F0	Port does not exist (0)
Port 05	16	Relay K1 set (1), control output port (6)
Port 06	F4	Analog output port (4)
Port 07	F4	Analog output port (4)

3.3.7 Local Output

Sends the requested output operation to the local relays. The user enters 8 bits of data as 2 hexadecimal digits. Data format is shown below.

```
 msb                           lsb
 -------------------------------
|K1R|K1S|K2R|K2S| X | X | X | X |      X = don't care
 -------------------------------
```

3.3.8 LED Output

Send display byte - (three hexadecimal digits) to the 8 LED status display board, (L1-L8) and the on board LED (L9). The byte format is as follows:

```
 ----------------    ----------------    ----
|L1 |L2 |L3 |L4 |   |L5 |L6 |L7 |L8 |   | L9|
 ----------------    ----------------    ----
```

3.3.9 CPU Port Test

This option is intended for testing MRTU Basic Module hardware only. The module should be disconnected from the radio and other MRTU modules when selecting this operation.

Screen Display:

```
0:  Menu
1:  Read Port A
2:  Read Port G
3:  PTT Set/Clear
4:  Modulator On/Off
5:  Pulse Duration Output High/Low
```

3.3.9.1 Read Port A

Reads port A of the 68HC11 CPU and displays hexadecimal data according to the following format:

```
msb                                              lsb
----------------------------------------------------
|ST#8 |CK    |PDO   |ADDR |BUSY |PDI    |READY|BREQ  |
----------------------------------------------------
```

Port	Signal	Desscription	Input/Output
PA7	ST#8	Status input #8	I
PA6	CK	Clock signal ("smart" bus)	0
PA5	PDO	Pulse duration output (modulation signal)	0
PA4	ADDR	Address signal ("smart" bus)	0
PA3	BUSY	Busy signal ("smart" bus)	0
PA2	PDI	Pulse duration input (demodulation signal)	I
PA1	READY	Ready signal ("smart" bus)	I
PA0	BREQ	Bus request ("smart" bus)	I

3.3.9.2 Read Port G

Reads port G of the SLIC and displays hexadecimal data according to the following format:

```
msb                                      lsb
--------------------------------------------
|DATA|OE1 |CM  |MODEN|PTT|ACPF|RLY2|RLY1|
--------------------------------------------
```

Port	Signal	Desscription	Input/Output
PG7	DATA	Data signal ("smart" bus)	I
PG6	OE1	Enable #1, relay output module enable	0
PG5	CM	Channel monitor status	I
PG4	MODEN	Modulator enable	0
PG3	PTT	Push-To-Talk status	0
PG2	ACPF	AC Power Fail	I
PG1	RLY2	Relay #2 Set	0
PG0	RLY1	Relay #1 Set	0

3.3.9.3 PTT Set/Clear (PG3) PTT

Enter the output data, PTT set or clear.

3.3.9.4 Modulator On/Off (PG4) Moden

Enter the output data, modulator on/off. When the modulator is on a 900 Hz or 1500 Hz frequency, the signal can be tested on the FST line (the FST level is adjusted via resistor R1).

3.3.9.5 Pulse Duration Output (PDO) High/Low (PA5)

Enter the output data, pulse duration high/low; it will change the frequency of FST to 1500 or 900 Hz (if the modulator is set to ON).

4. 8 LEDs DIAGNOSTICS

4.1 DIAGNOSTIC CHECKLIST

MRTU Basic module diagnostics are executed from four locations in the software:

a. POWERUP HARDWARE/SOFTWARE CHECKS
b. STARTUP HARDWARE CHECKS
c. RUNTIME HARDWARE/APPLICATION CHECKS
d. CPU INTERRUPTS FOR HARDWARE CHECKS

Diagnostic checks include the following tests:

TESTS	DESCRIPTION
a. RAM CHECK (Power-up only)	writes and reads entire RAM
b. RUNTIME RAM CHECK	checks patterns scattered in RAM
c. EEPROM CHECK	writes and reads entire EEPROM (executed on first powerup only)
d. RUNTIME EEPROM CHECK	read database checksum in runtime
e. EPROM CHECK	checks checksum of entire EPROM
f. A/D VOLTAGE CHECK	samples a/d reference voltages
g. WATCHDOG TIMER	on powerup, checks watchdog timer interrupt
h. COMMUNICATION FAILURE	detects communication failure after parameter timeout (presets relays)
i. RELAY BACK-INDICATION CHECK	checks relay state against current relay value
j. LOW BATTERY	detects low battery voltage (analog value) and suspends transmission according to parameter
k. AC POWER FAIL	detects AC power fail (ACPF signal)

l.	EXTERNAL MODULES CHECK	checks that all defined modules exist and are of the correct type (analog, status, relays)
m.	CLOCK MONITOR CHECK	checks microprocessor clock frequency
n.	ILLEGAL OPCODE TRAP	detects invalid opcode
o.	COMPUTER OPERATING PROPERLY	Watchdog timer check
p.	BCH/PCH ERROR DETECT	INTRAC 2000 codeword error
q.	SERIAL PORT ERROR	all SCI errors.

Diagnostic checks are executed as follows:

4.1.1 Powerup Hardware/Software Checks

RAM CHECK
EEPROM CHECK - first powerup
EPROM CHECK
A/D VOLTAGE CHECK
WATCHDOG TIMER
EXTERNAL MODULES CHECK

4.1.2 Runtime Hardware/Application Checks

RUN-TIME RAM CHECK
COMMUNICATION FAILURE
RELAY BACK-INDICATION CHECK
EXTERNAL MODULES CHECK
LOW BATTERY
AC POWER FAIL

4.1.3 CPU Hardware Checks

CLOCK MONITOR RESET
ILLEGAL OPCODE TRAP
COMPUTER OPERATING PROPERLY

4.2 SHUT UP

The following errors will cause a SHUTUP and will stop all module activities. After 1 second the watchdog timer will cause a hardware reset.

CLOCK MONITOR RESET
ILLEGAL OPCODE TRAP
RAM ERROR
EEPROM ERROR
EPROM ERROR
A/D VOLTAGE ERROR
WATCHDOG TIMER

4.3 RADIO COMMUNICATION

The following errors are reported to the central via radio communication.

Errors	Description
COMMUNICATION FAILURE	CF bit in internal indications byte
LOW BATTERY	Low battery bit in internal indications byte
AC POWER FAIL	Bit 24 in every reported status group
RELAY BACK-INDICATION CHECK	ERR bit in internal indication byte
BCH/PCH ERROR DETECT	C.ERR bit in internal indications byte.

4.4 ERROR LOGGING

The following errors are logged in RAM/EEPROM:

Error	Location
DELAY BACK-INDICATION CHECK	RAM (port numbers)
DEFINED MODULES CHECK	RAM (port numbers)
CLOCK MONITOR RESET	EEPROM (bit flag)
ILLEGAL OPCODE TRAP	EEPROM (bit flag)
RUN-TIME RAM CHECK	EEPROM (bit flag)
COMPUTER OPERATING PROPERLY	EEPROM (bit flag)
BCH/PCH ERROR	RAM

Errors will be deleted from the log after the CLEAR ERR (CLE) command is given via the RS-232 serial port.

4.5 REPORTING

Diagnostic reporting will be performed via the following:

a. LED DISPLAY
b. SERIAL PORT OUTPUT
c. RADIO COMMUNICATION

4.5.1 LED Display

During normal operation the LEDs will display the local inputs state. Pressing the test pushbutton will light the LEDs for 1 second and then the current error LEDs will light up (if there are errors).

After pressing the test button, eight LEDs will display the current diagnostic errors.

LED #	Description
1	Communication Fail
2	Serial Port Error
3	AC Fail
4	Relays Back-Indication Error, or Analog Output Error
5	Analog Input or Counter Module Error
6	External Module Definition Error (Analog/status mixed)
7	SLIC operates properly (lit when the gate array U9 is OK)
8	Low Battery

If SHUTUP occurs LED #8 will blink and the error is indicated by one of the following LEDs being lit:

LED #	Description
1	RAM
2	EEPROM
3	EPROM
4	A/D VOLTAGE
5	WATCHDOG TIMER
8	SHUTUP

NOTE

Pressing the test pushbutton during SHUTUP mode will not affect the display.

4.5.2 Serial Port Output

All logged error messages will be sent to the serial output port after the ERROR (ERR) command is enabled from the serial input port (via the terminal).

4.5.3 Radio Communication

Errors will be reported to the central as they occur according to internal indication byte. During startup the EEPROM error byte will be checked, and the ERR bit will be set in the internal indication byte (if requested). To enable error reporting via radio use the FRN1785 Field Configuration Program. The default setting is disable.

5. ELEMENTARY TROUBLESHOOTING FOR MRTU

5.1 POWER

5.1.1 AC/DC Power Fail

For model with power package PS-8.

A. Is the LED on the PS-8 on ?

- If not, check ac fuse, ac cable and connection.

B. Check if JU9 (in the MRTU Basic Module) is inserted.

5.1.2 AC Power Fail

For model with ac adaptor, 24 Vdc option or model F6799, check fuse on the power supply charger FLN4847A.

5.1.3 Battery Power Fail

For model with power package PS-8, check the battery fuse, and that JU8 in the MRTU Basic Module is inserted.

5.2 TRANSMISSION

Trouble: No transmission when pressing the radio test pushbutton on the MRTU basic module pc board.

A. If FSK level is low, turn the potentiometer on the MRTU Basic module PC board clockwise, and/or the potentiometer on the FLN4948A Radio Interface PC board (if available).

B. If Channel Monitor (CM) polarity is wrong, change the CM polarity or enable a CM override and test again.

C. If no-transmitting-on-low-battery parameter is set to "Yes" and the battery is low, set the parameter to "No" and test again.

D. If operating with an HT440 radio, check the battery fuse (first remove the NiCad battery).

E. The trunking radio system parameter is set to "Y" for a non-trunking system.

5.3 RECEPTION

Trouble: No Reception

A. If the PLL demodulator is not adjusted, adjust the demodulator.

B. If the receive-by-CM condition is set to "Yes", set it to "No" and try again.

Trouble: Faulty Interrogation

The unit will answer an interrogation only when bit 15 is set to "1" (word from central).

Trouble: Faulty Download Command (Mask, Freeze, Analog Set Limit etc.)

A. The unit accepts the download command only if bit 15 is set to "1" (word from central).

B. The enable-download command parameter must be set to "Yes".

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THEORY OF OPERATION

1. GENERAL

The MRTU Basic Module Main Board consists of a number of circuits, listed below. Refer to the functional block diagram located on page 5.

- Voltage Regulator circuit
- User I/O interface
- CPU
- FSK modulator
- FSK demodulator
- External I/O interface
- Radio Interface

2. VOLTAGE REGULATOR CIRCUIT

This circuit provides the necessary operating voltages required for the MRTU Basic Module and other MRTU modules connected via the MRTU bus. The various voltages are listed in Table 1. Additional Basic Module power data is presented in Tables 2 and 3.

Table 1. Voltages

Voltage	Symbol	Destination/s
5 V	VCC	Logic, MRTU bus, status display
12-15 V, 50 mA	VBAT	Ni-Cad battery charge current
12 V - 15 V	VD	Relays, modulator, MRTU bus
8 V	VBB	Demodulator, RS-232 port
-7.3 V	VEE	RS-232 port
2.5 V	VRH	Reference voltage for the microprocessor
1.25 V	VRH/2	Reference voltage for the analog inputs

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In addition, the circuit supplies a PF (Power Fail) signal that resets the microprocessor if VCC drops below 4.75 V. An AC POWER FAIL (ACPF) signal (active low) detects loss of ac power. The source of the ACPF is the power supply charger when the input voltage is 22-28 V ac/dc, or external when the input voltage is 12 Vdc. For external power supplies that do not output an ac power fail signal, the ACPF signal should be connected to ac/dc (12 V input) in order to avoid a constant ACPF signal.

Table 2. Power Supply Jumpers

Jumper Symbol	Function	Positions	
		In	Out
JU7	Vbat source	12 Vdc (Vbat=Vd)	24 Vac (Vbat from PS charger)
JU9	External PS	12 Vdc	24 Vac
JU8	AC power fail indication	External (J6-14)	Internal (PS charger)

Table 3. Power Inputs at User Connector (J6)

J6	12	13	14
Power from 24 V ac/dc	GND	ac/dc high	ac/dc low
Power from -24V dc	Pos. GND	-24 Vac	GND
Power from 11 V- 15 Vdc	GND	11V-15Vdc	ACPF

3. USER I/O INTERFACE

The user I/O interface circuit provides the interface between the user connections (14-pin user connector), and the CPU. Refer to Table 4 on the next page.

All I/O lines are protected against surges according to IEEE-472 standard.

The status inputs include an RC filter of 0.1 ms time constant. An additional parameterized filter is provided by software.

Table 4. Inputs/Outputs at User Connector (J6)

Option	Pin Number 1	2	3	4	5	6	7	8	9	10	11	12
DEFAULT	K1NO	K1C	IN1	IN2	IN3	IN4	GND	IN5	IN6	IN7	IN8	GND
V377	K1NO	K1C	K2NO	K2C	IN3	IN4	GND	IN5	IN6	IN7	IN8	GND
V378	K1NO	K1C	IN1	IN2	IN3	IN4	GND	IN5	IN6	AN1+	AN1-	GND

Legend (Examples)

K1NO-Relay K1 normally open
K2C-Relay K2 normally closed
AN1-Analog Input 1, where + indicates the high end and - indicates the low end
IN1-Input 1

4. CPU

The CPU sub-circuit is based on the 68HC11A1 microcomputer (U8), utilizing its enhanced processing power, EEPROM memory, A/D converters, Serial Peripheral Interface (SPI), and Serial Communication Interface (SCI). An 8k SRAM, and 32k static EPROM are external to the CPU.

A gate array device named SLIC (Support Logic IC), in a 68-pin PLCC case performs the following functions:

- port expander
- address demultiplexer
- external memory select decoder

Additional CPU features

CPU clock rate: 2.0 MHz
External interrupts: none
Reset: Performed upon power up, power down (VCC < 4.75 V) or processor's hardware watchdog timer.

5. FSK MODULATOR

The FSK modulator is based upon the XR2206 FSK generator Integrated Circuit (U7). The input to the modulator is Pulse Duration Input (PDI) from the CPU. The FSK frequencies are set by the values of capacitor C2, and resistors R2 and R3.

$$F_1 = \frac{1}{R2 \times C2} \qquad F_2 = \frac{1}{R3 \times C2}$$

The basic application is set for 900/1500 Hz only. Resistors R8 and R9 have been included for anticipated operation at 1000/1600 Hz frequencies. In such applications, one of two pairs of frequencies may be chosen via jumpers JU3 and JU4. Potentiometer R1, located near the latch door of the module, sets the FSK transmit (FST) level linearily between 3 mV rms to 0.5 V rms at a 600 ohm load. When in operation, the modulator normally draws up to 20 mA current and outputs a frequency dependant on the PDO signal. The MOD EN signal from the CPU (U9-22) shuts down the modulator for current saving applications.

6. FSK DEMODULATOR & TRUNKED RADIO SUPPORT

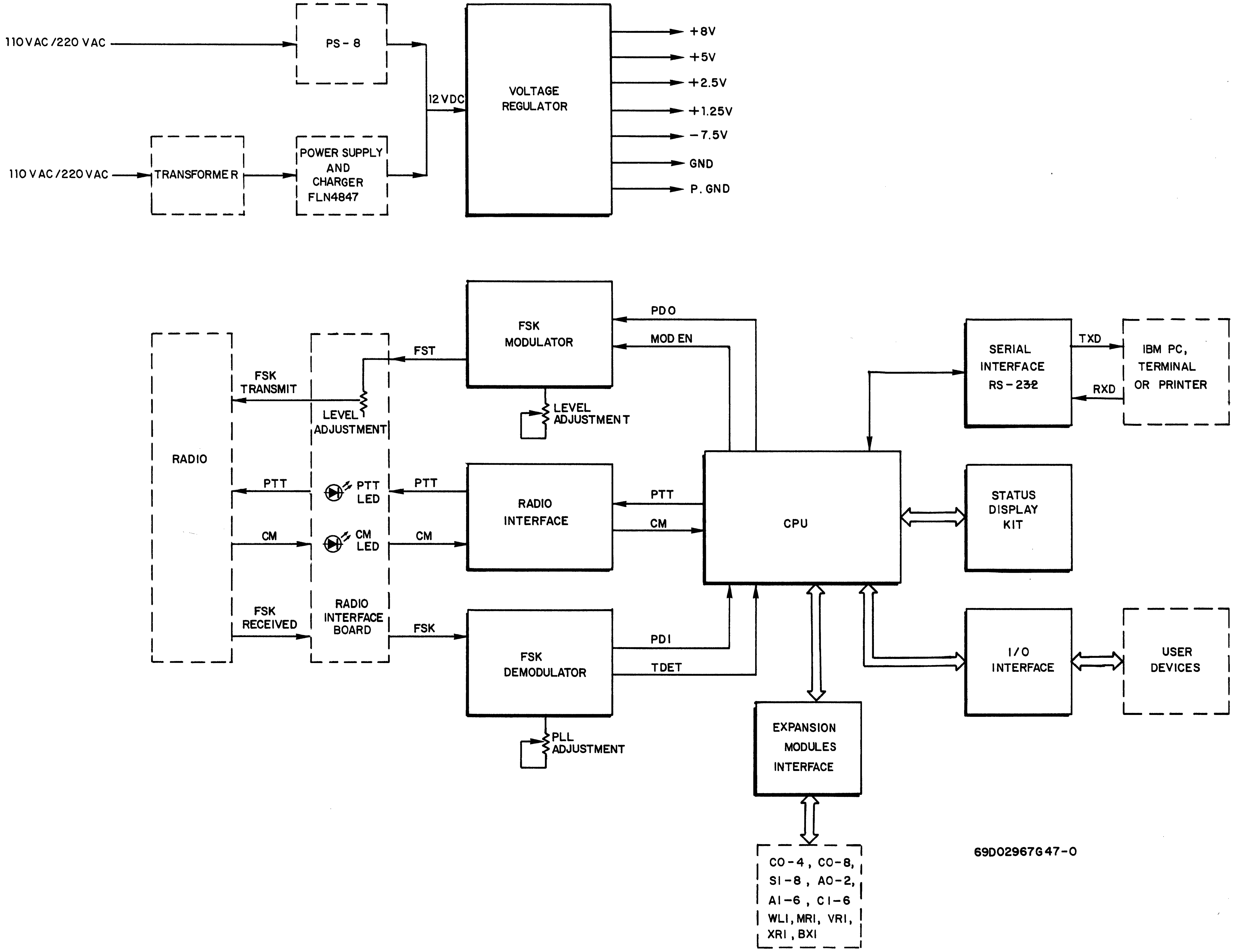
The FSK demodulator is based upon the XR2211 IC (U5). FSK receive (FSR) tones are routed through a bandpass filter and enter the FSK PLL (U5-2). The output from the phase detector within U5 is applied to the PLL filter at U5-11 for high filter rejection. The signal with no phase error is applied to U5-8, and enters the FSK comparator within U5. The output of U5-7 is the Pulse Duration Input (PDI) signal. U5-6 and its complement U5-5 are open collector lock detect outputs. U5-6 is connected to the CPU as a tone detect signal. R28 and C21 eliminate the chatter of the lock detect outputs. R16 and R27, which are connected to U5-12, set the PLL center frequency.

7. EXTERNAL I/O INTERFACE

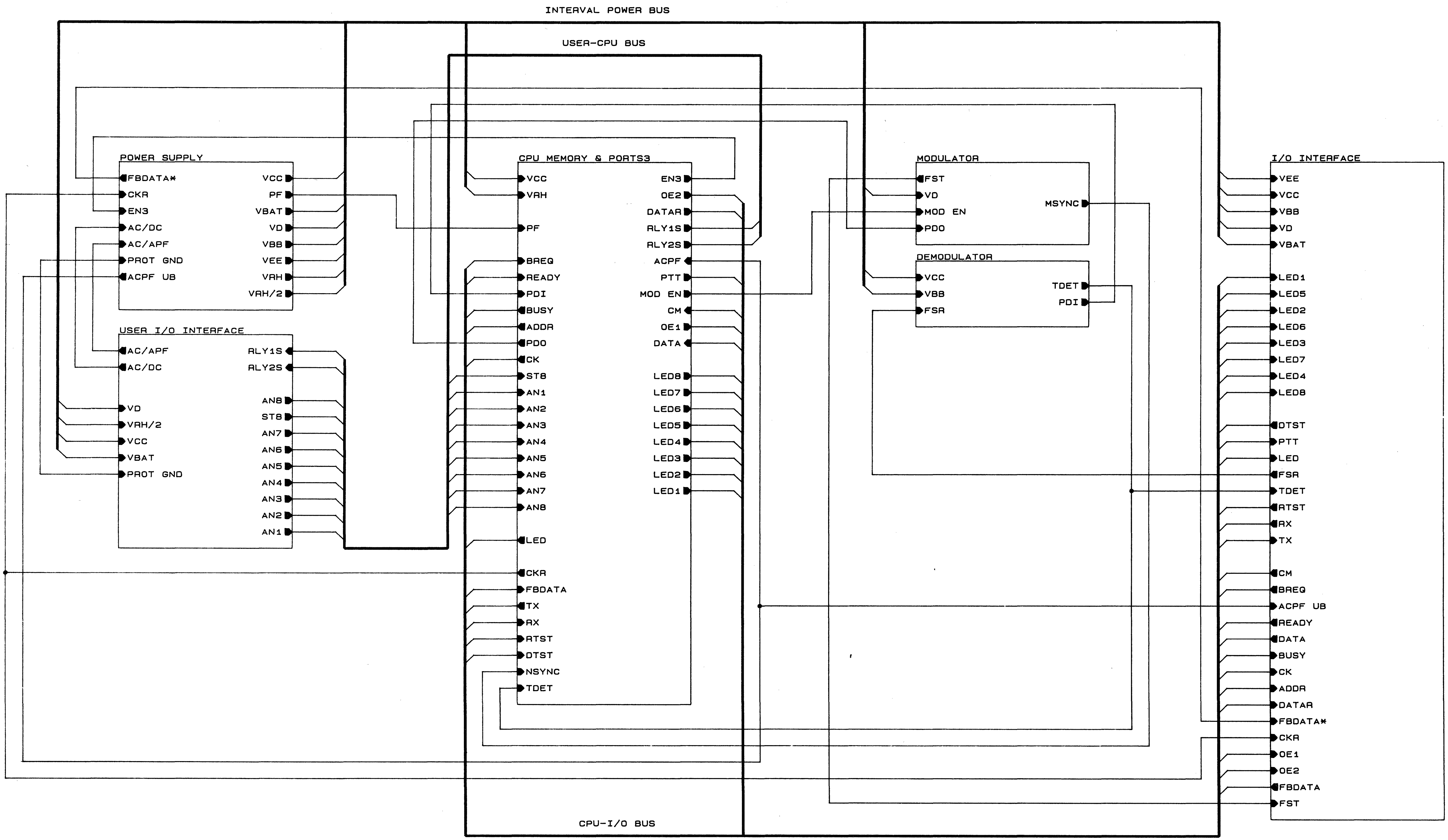
The External I/O interface provides protection to the signals received by the CPU from outside the MRTU Basic module. This includes signals from MRTU expansion modules (via bus connector J4); from the Status Display kit (via J5); from the radio (via J3); and signals from an INTRAC test set, a terminal or a computer, via the test connector. U19 shifts the logic levels between the CPU (SCI) and the RS-232 standard levels.

8. RADIO INTERFACE

This circuit interfaces between the main board and the external Radio Interface board FLN4948. Diode protection against overvoltage is provided for the channel monitor (CM) signal. A switching transistor controls the PTT on the Radio Interface board.



FLN4649A MRTU Basic Module Main Board
Functional Block Diagram
November, 1988



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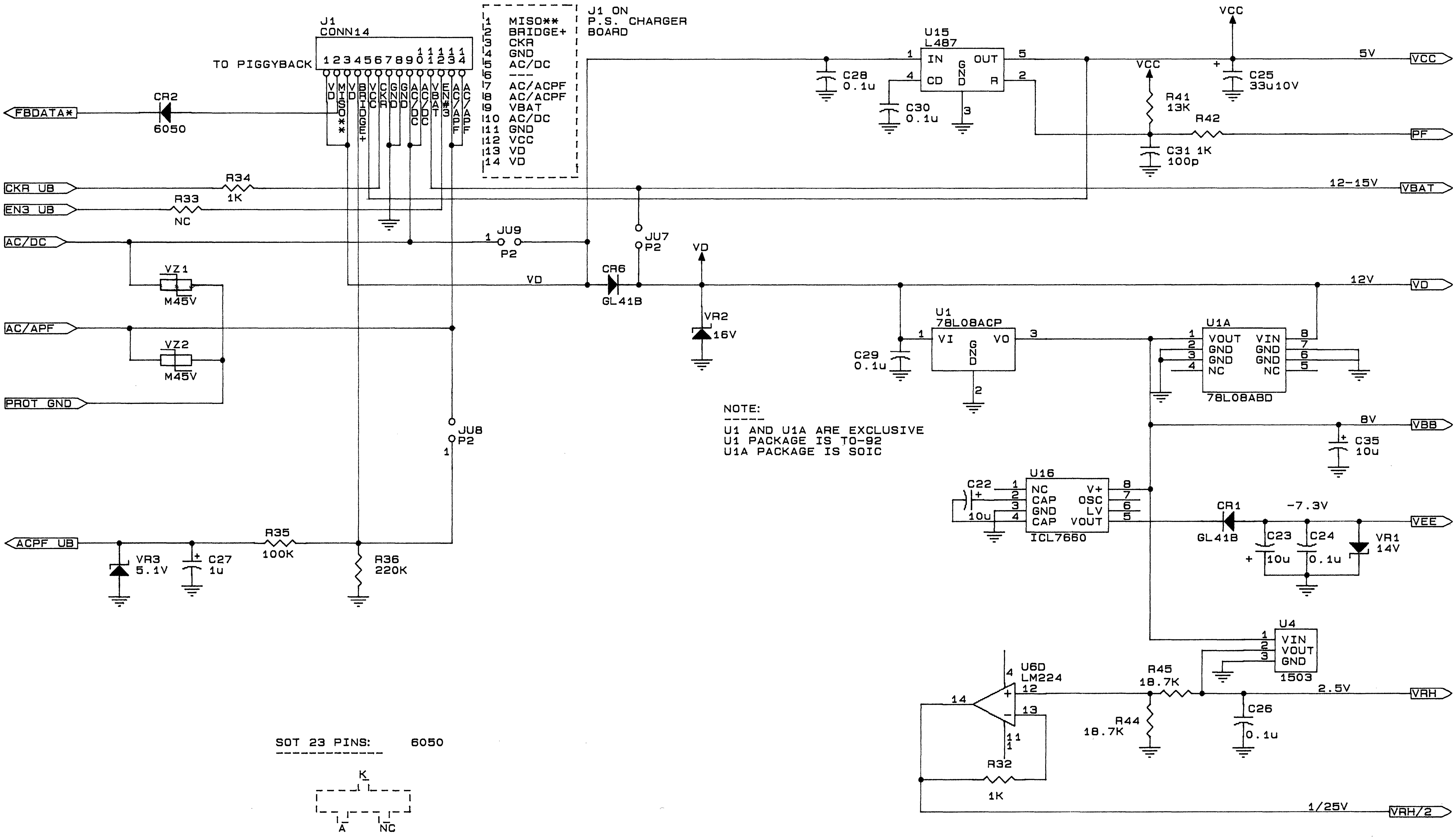
FLN4649A MRTU Basic Module Main Board
Interconnect Diagram
November, 1988

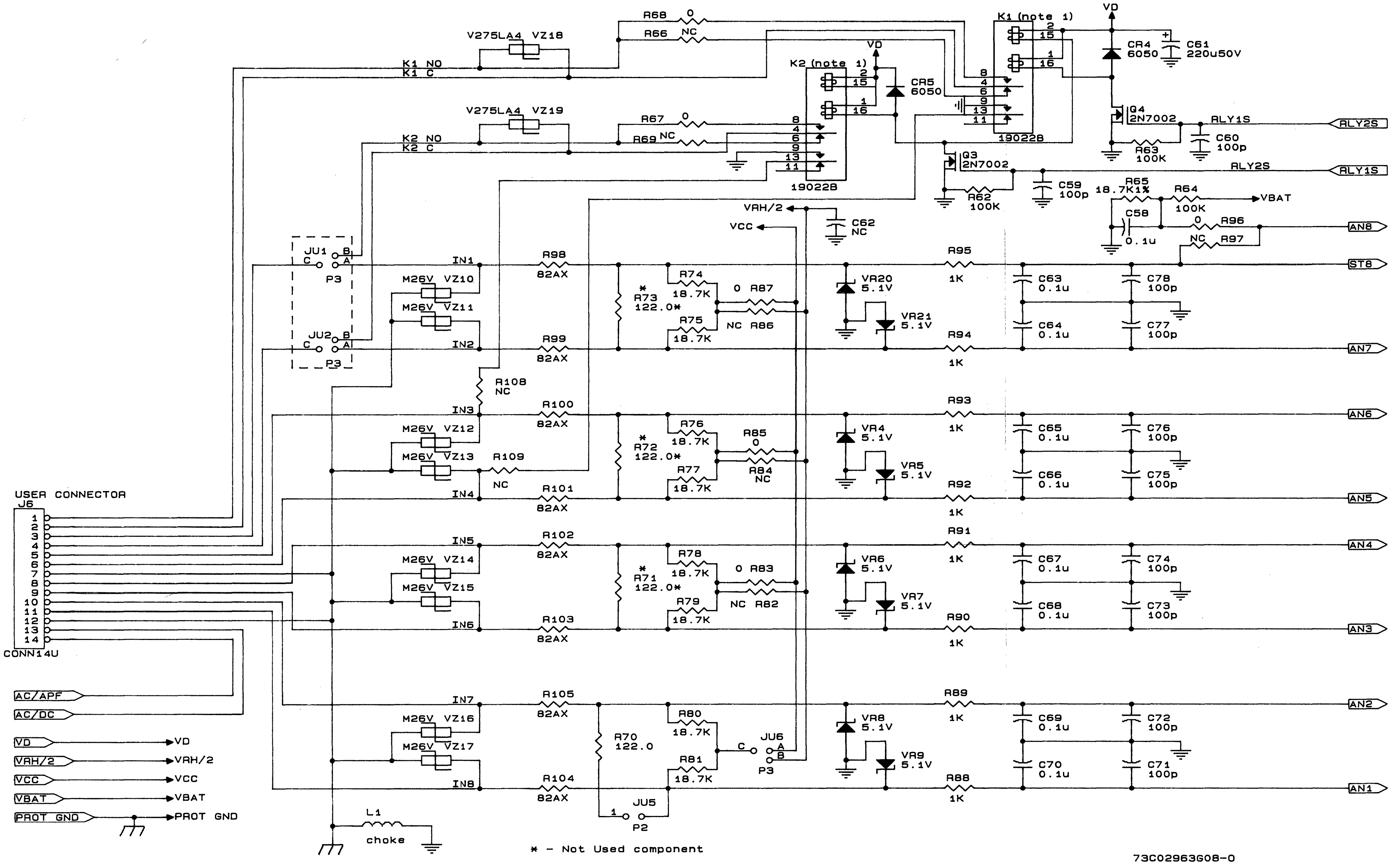


NOTE:

U1 AND U1A ARE EXCLUSIVE
U1 PACKAGE IS TO-92
U1A PACKAGE IS SOIC

73B02963G03-0

Voltage Regulator Circuit
Schematic Diagram
November, 1988

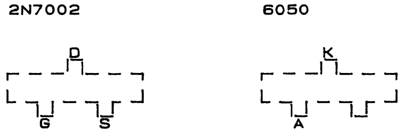


NOTES:

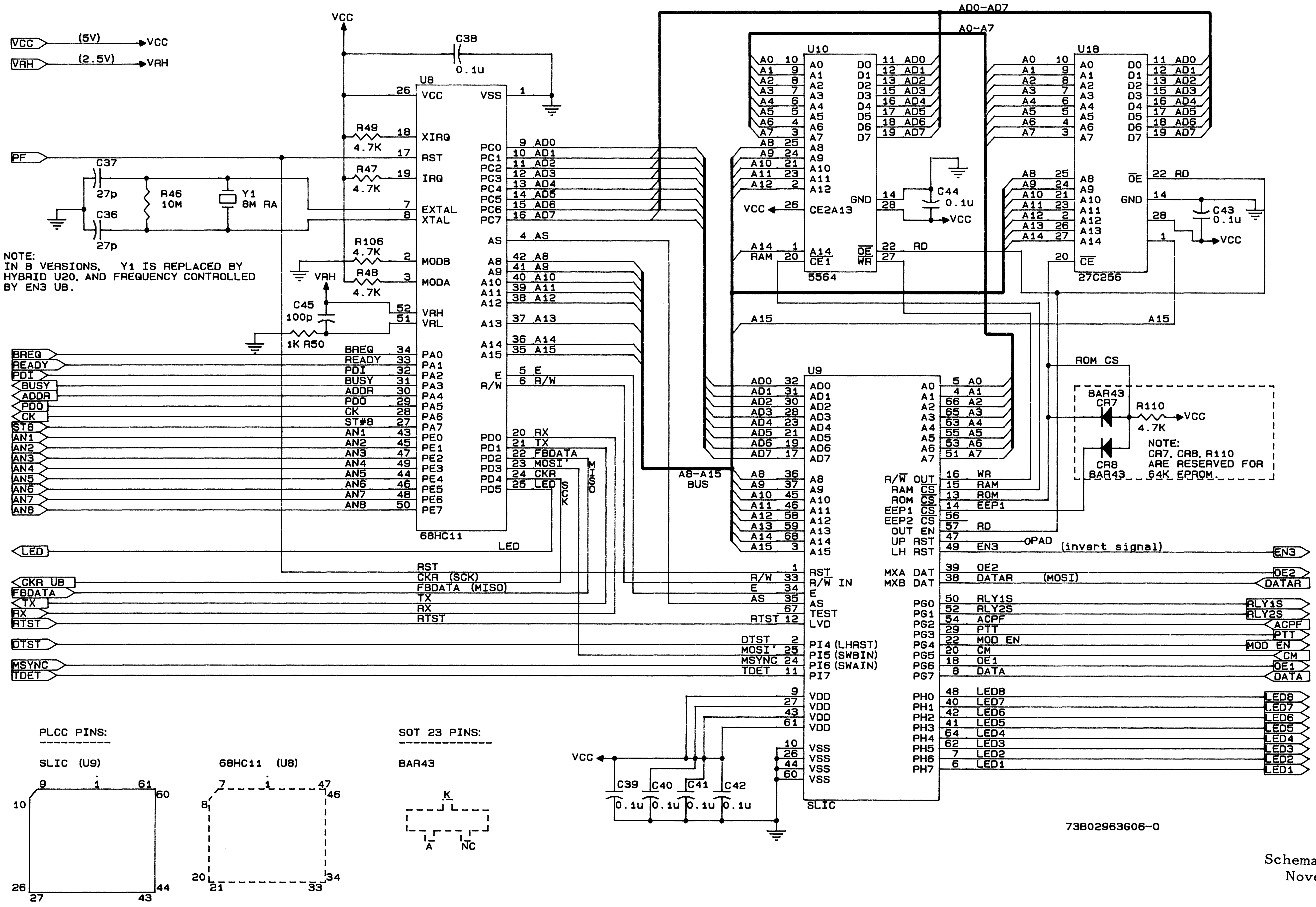
1. THE RELAYS IN USE ARE MOMENTARY RELAYS WITH ONE COIL ONLY BETWEEN PINS 1-16.

2. NC = NOT CONNECTED

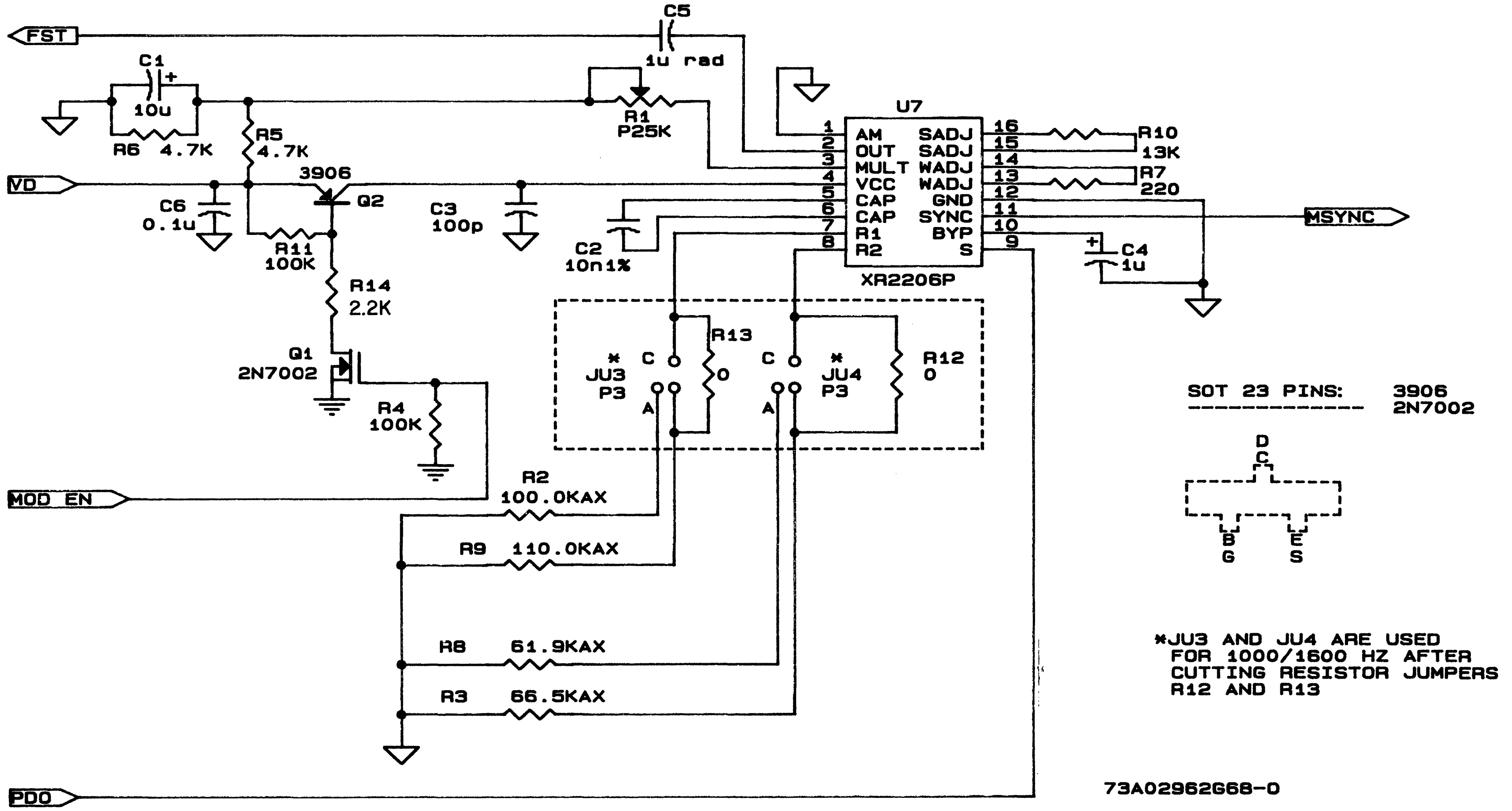
SOT 23 PINS:



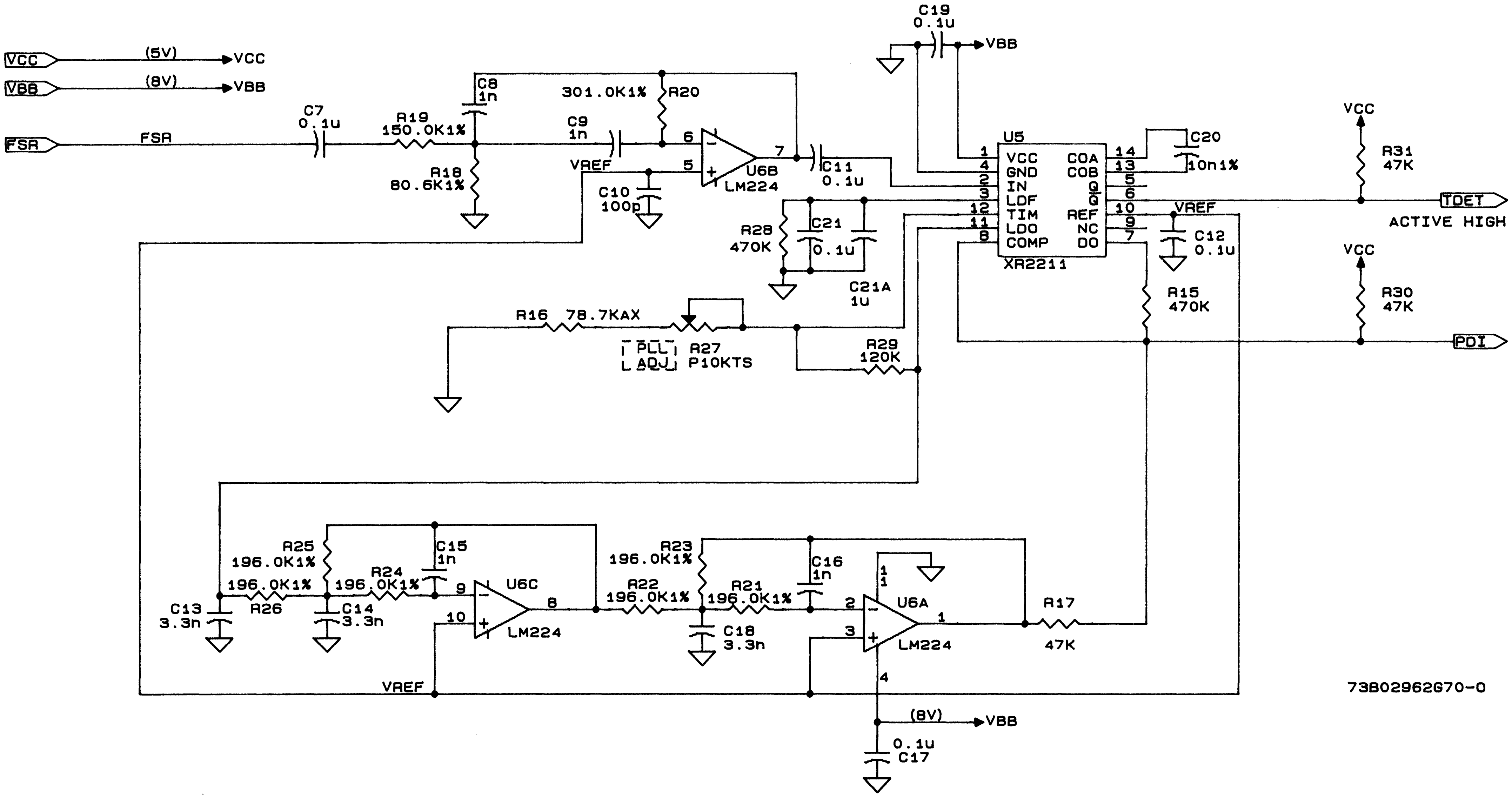
User I/O Interface
Schematic Diagram
November, 1988



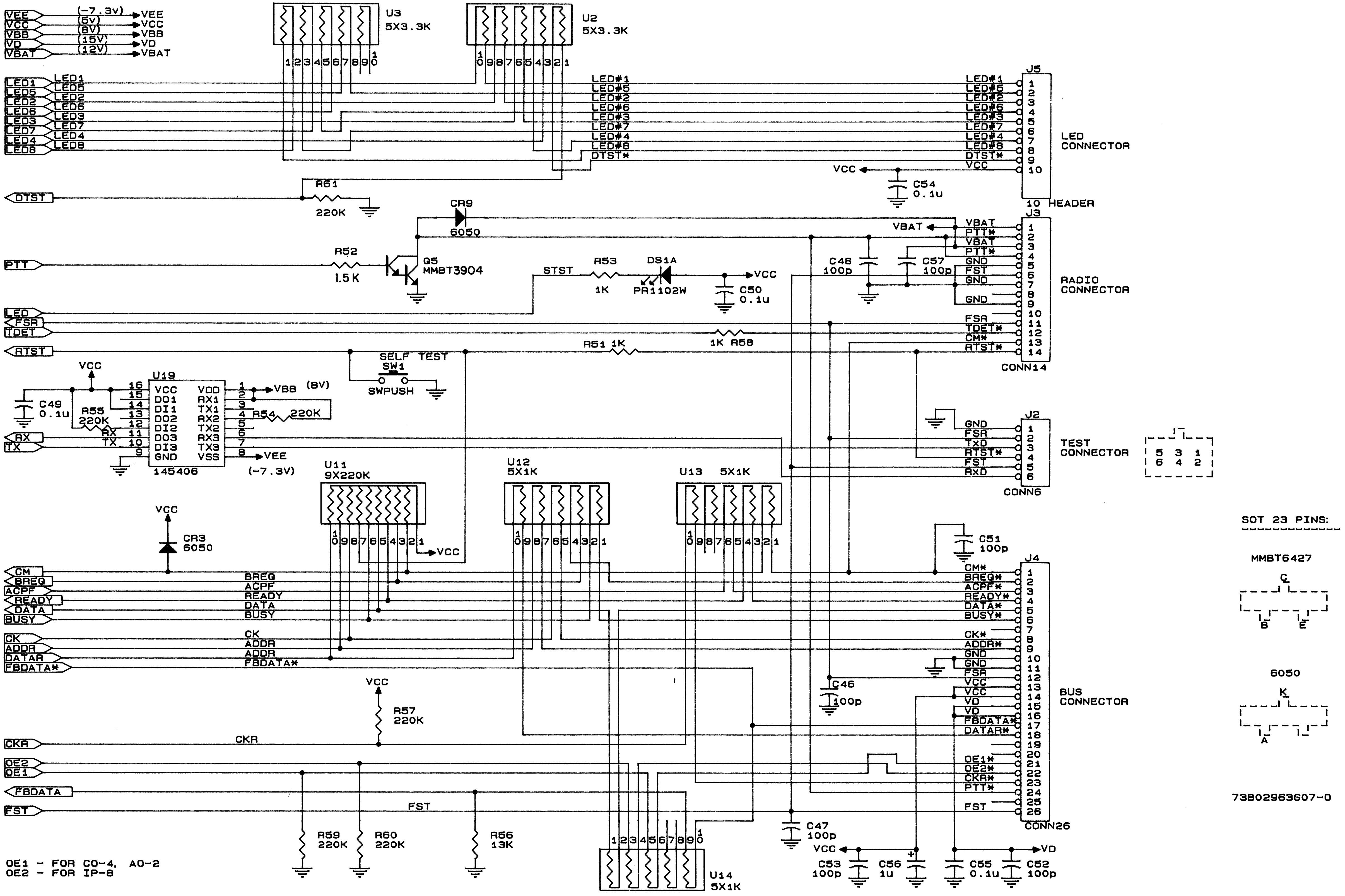
CPU
Schematic Diagram
November, 1988



FSK Modulator
Schematic Diagram
November, 1988



FSK Demodulator
Schematic Diagram
November, 1988



OE1 - FOR CO-4, AO-2
OE2 - FOR IP-8

73802963G07-0

External I/O Interface
Schematic Diagram
November, 1988

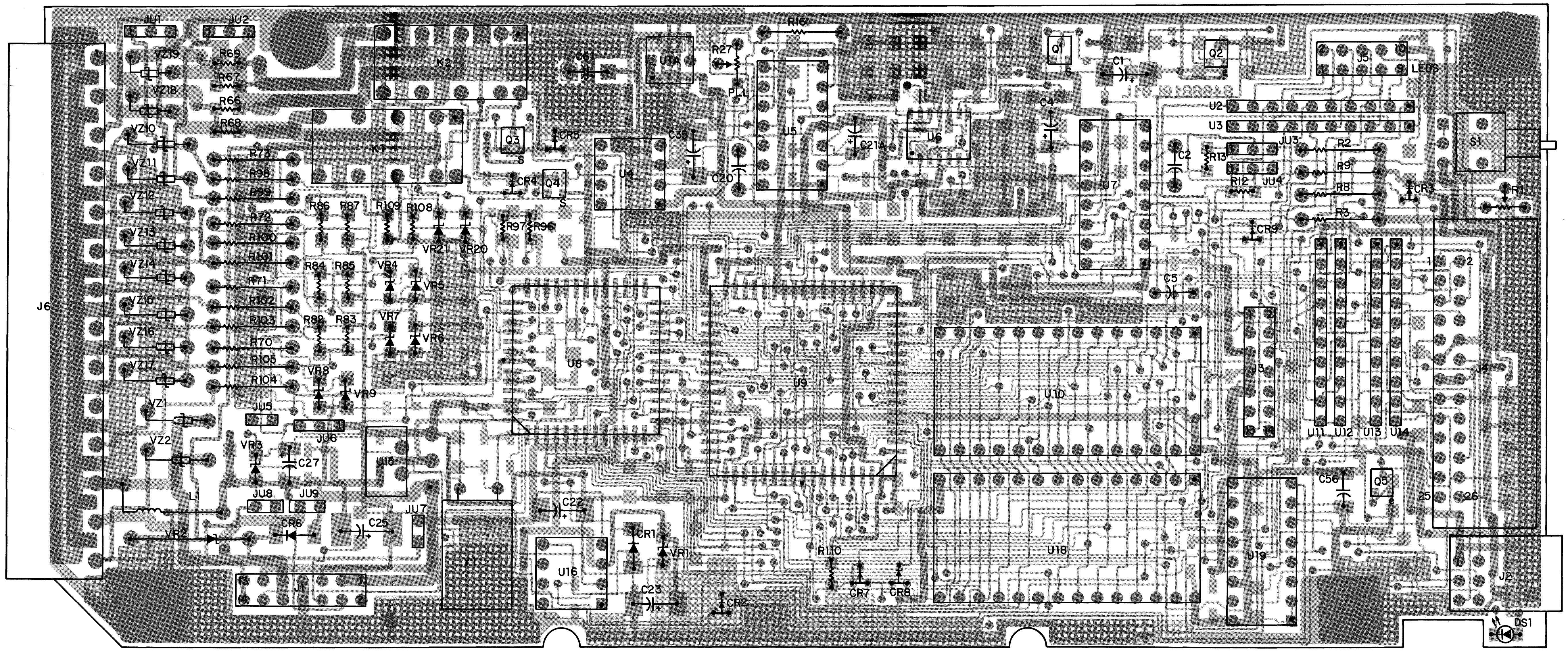
parts lists

FLN4649A MRTU Basic Module Main Board PL-0932-O

Reference Symbol	Motorola Part No.	Description
		Capacitor
C1	23-11066A14	10 uF; 20% 10V chip
C2	21-02384C06	10 nF 1% 100V NPO
C3	21-11031A39	100 pF; 50V chip
C4	23-11066A06	1 uF; 20%; 35V tant. chip
C5	21-08029H07	1 uF; 50V, radial
C6, C7	21-11032A33	0.1 uF; 10%; 50V
C8, C9	21-11031A61	1 nF; 50V chip
C10	21-11031A39	100 pF; 50V
C11, C12	21-11032A33	0.1 uF; 10%; 50V
C13, C14	21-11032A15	3.3 nF chip
C15, C16	21-11031A61	1 nF; 50V chip
C17	21-11032A33	0.1 uF; 10%; 50V
C18	21-11032A15	3.3 nF chip
C19	21-11032A33	0.1 uF; 10%; 50V
C20	21-02384C06	10 nF 1% 100V NPO
C21	21-11032A33	0.1 uF; 10%; 50V
C21A	23-11066A06	1 uF; 20%; 35V tant. chip
C22, C23	23-11066A14	10 uF; 20% 10V chip
C24	21-11032A33	0.1 uF; 10%; 50V
C25	23-11066A08	33 uF; 20% 10V chip
C26	21-11032A33	0.1 uF; 10%; 50V
C27	23-11066A06	1 uF; 20%; 35V tant. chip
C28-C30	21-11032A33	0.1 uF; 10%; 50V
C31	21-11031A39	100 pF; 50V
C32-C34	----	Not used
C35	23-11066A14	10 uF; 20% 10V chip
C36, C37	21-11031A25	27 pF; 50V chip
C38-C44	21-11032A33	0.1 uF; 10%; 50V
C45-C47	21-11031A39	100 pF; 50V
C48		not used
C49, C50	21-11032A33	0.1 uF; 10%; 50V
C51-C53	21-11031A39	100 pF; 50 V
C54, C55	21-11032A33	0.1 uF; 10%; 50V
C56	23-11066A06	1 uF; 20%; 35V tant. chip
C57	21-11031A39	100 pF; 50 V
C58	21-11032A33	0.1 uF; 10%; 50V
C59, C60	21-11031A39	100 pF; 50V
C61	23-02166C07	220 uF; 50V, radial
C62	----	Not used
C63-C70	21-11032A33	0.1 uF; 10%; 50V
C71-C78	21-11031A39	100 pF; 50V
		Diode (see Note 2)
CR1	48-82960R02	chip GL41B
CR2-CR5	48-11058B11	MMBD6050 SOT diode
CR6	48-82960R02	chip GL41B
CR7, CR8	48-08115L03	BAR43 Schottky SOT, not in use, reserved for 644 EPROM
CR9		not used
		LED
DS1	48-02579S02	red LED, chip
		Connector
J1	28-08044H01	14-pin p.s. connector
J2	28-08514G02	6-pin test connector
J3	28-08044H01	14-pin radio connector
J4	28-08044H06	26-pin bus connector
J5	28-08044H04	10-pin display connector
J6	28-08508G04	14-pin user connector
		Jumper
JU1-JU4	28-84318M07	3-pin jumper
JU5	28-80141H04	2-pin jumper
JU6	28-84318M07	3-pin jumper
JU7-JU9	28-80141H04	2-pin jumper
		Relay
K1, K2	80-84090N03	momentary 2 form C
		Coil
L1	24-83977B02	Choke
		Transistor (see note 2)
Q1	48-80182D47	VMOS SOT, 2N7002
Q2	48-82233P14	PNP SOT, 3906
Q3, Q4	48-80182D47	VMOS SOT, 2N7002
Q5	48-11056C21	MMBT3904
		Resistor, fixed ±5% 1/8 W unless otherwise stated
R1	18-02467C25	25k; 10% potentiometer
R2	06-10621D88	100k 1% axial; 1/4 W
R3	06-10621D71	66.5k 1% 1/4W axial
R4	06-11077B23	100k chip
R5, R6	06-11077A90	4.7k chip
R7	06-11077A58	220 chip
R8	06-10621D68	61.9k 1%; 1/4W axial
R9	06-10621D92	110k 1% axial; 1/4W
R10	06-11077B02	13k chip
R11	06-11077B23	100k chip
R12, R13	06-11077A01	0 ohm jumper chip
R14	06-11077A82	2.2k chip
R15	06-11077B39	470k 5% chip
R16	06-10621D76	75.0k 1%; 1/4W axial
R17	06-11077B15	47k; 5% chip
R18	06-11077G79	80.6k; 1% chip
R19	06-11077H06	150k; 1% chip
R20	06-11077H35	301k; 1% chip
R21-R26	06-11077H17	196k; 1% chip
R27	18-02467C01	10k potentiometer
R28	06-11077B39	470k 5% chip
R29	06-11077B25	120k; 5% chip
R30, R31	06-11077B15	47k; 5% chip
R32-R34	06-11077A74	1k chip
R35	06-11077B23	100k chip
R36	06-11077B31	220k chip
R37-R40	----	Not used
R41	06-11077B02	13k chip
R42	06-11077A74	1k chip
R43		Not used
R44, R45	06-11077G18	18.7k chip
R46	06-11077C16	10M 10% chip
R47-R49	06-11077A90	4.7k chip
R50, R51	06-11077A74	1k chip
R52	06-11077A78	1.5 k chip
R53	06-11077A74	1k chip
R54, R55	06-11077B31	220k chip
R56	06-11077B02	13k chip
R57	06-11077B31	220k chip
R58	06-11077A74	1k chip
R59-R61	06-11077B31	220k chip
R62-R64	06-11077B23	100k chip
R65	06-11077G18	18.7k; 1% chip
R66		Not used
R67, R68	06-11077A01	0 ohm jumper chip
R69		Not used
R70	06-08563C16	122 ohm; 0.1% 1/4W; 25ppm axial
R71-R73		Not used
R74-R81	06-11077G18	18.7k chip
R82		Not used
R83	06-11077A01	0 ohm jumper chip
R84		Not used
R85	06-11077A01	0 ohm jumper chip
R86		Not used
R87	06-11077A01	0 ohm jumper chip
R88-R95	06-11077A74	1k chip
R96	06-11077A01	0 ohm jumper chip
R97		Not used
R98-R105	06-11009C23	82 axial; 1/4W; 5%
R106	06-11077A90	4.7k chip
R107		not used
R108-R110		Not used
		Switch
SW1	40-08242G04	momentary, pushbutton
		Integrated Circuit (see Note 2)
U1	51-07379J01	8V regulator; 78L08ACP TO-92 (see Note 1)
U1A	51-08858K10	8V regulator; 78L08ABD SOIC (see Note 1)
U2, U3	51-02599K38	SIP, 5X 3.3k
U4	51-02162C59	2.5 V; regulator MC1503A
U5	51-02162C77	FSK demodulator; XR2211P
U6	51-08858K06	LM224, QUAD OPAMP
U7	51-02379L05	FSK modulator; XR2206PS
U8	51-02187C33	MC 68HC11A1/FN
U9	51-82862N09	68-pin PLCC gate array
U10	51-02156C48	S-RAM TC5564P-15, 8k (may also be 32k)
U11	51-02599K14	SIP; 9X220k
U12-U14	51-80007J17	SIP; 5X1k
U15	51-02190C30	5V reg. w/reset L487V
U16	51-02162C51	ICL7660, voltage conv.
U17		not used
U18	01-98213140	8 k EPROM
U19	51-02379L04	Driver/receiver MC15406
		Zener Diode (Note 2)
VR1	48-82958R57	MLL5244; 14V (MLL34)
VR2	48-02064C77	1N5353B, 16V
VR3-VR9	48-82958R44	MLL5231; 5.1V (MLL34)
VR10-VR19		Not used
VR20, VR21	48-82958R44	MLL5231; 5.1V (MLL34)
		Varistor
VZ1, VZ2	06-02597K06	MOV; 45 Vdc
VZ3-VZ9		Not used
VZ10-VZ17	06-02597K17	MOV; 26 Vdc
VZ18, VZ19	06-02597K16	MOV; 275 Vac
		Crystal (Note 2)
Y1	48-82611M25	8 MHz crystal R.A.
	Non Referenced Items	
	84-08810L01	printed circuit board
	09-82280R10	28-pin socket
	29-02219K01	terminal jumper
	32-82881P01	Gasket, HSET XTAL
	36-02140C13	Polarizing key
	43-80218E01	Spacer, MTG TSTR

Notes:

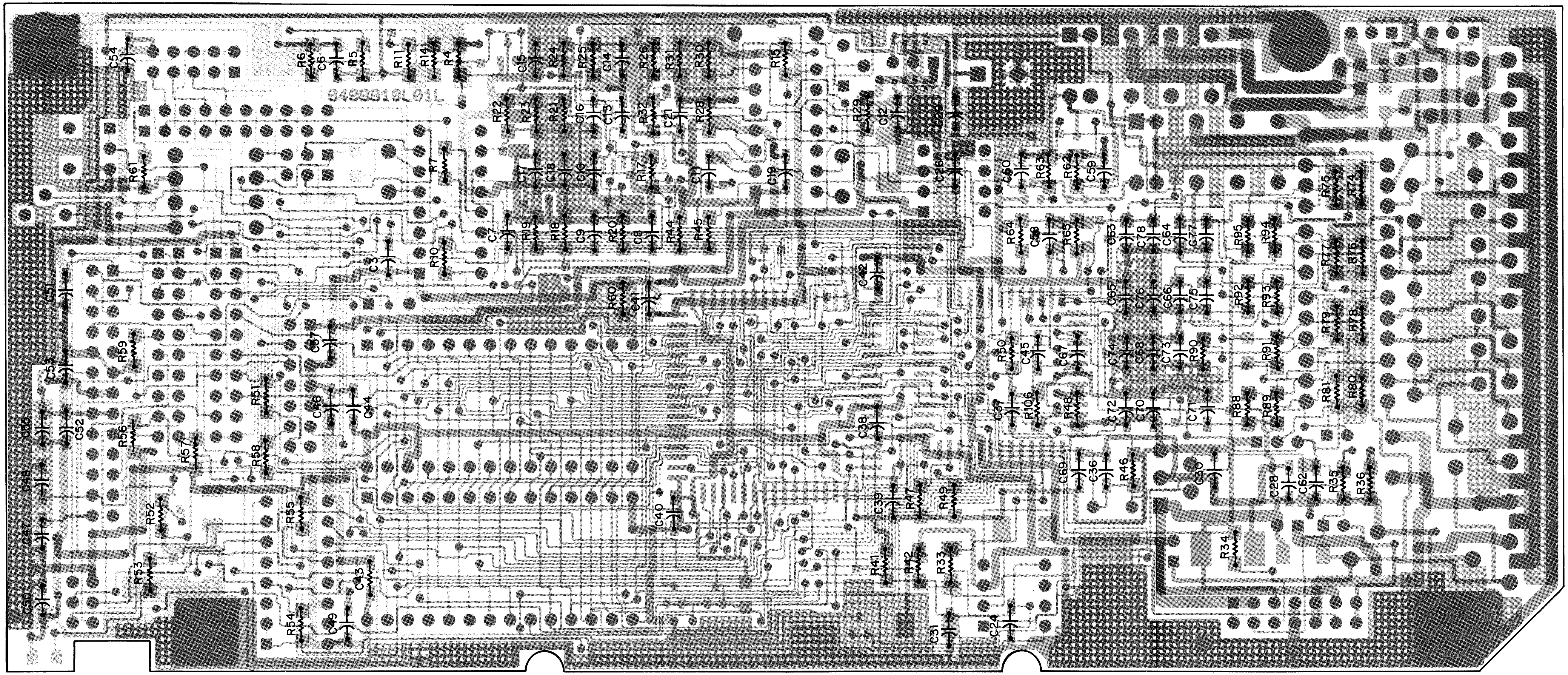
1. U1 and U1A are exclusive.
2. For optimum performance diodes, transistors and integrated circuits must be ordered by Motorola part numbers.



SHOWN FROM COMPONENT SIDE

OVERLAY ● 79D02965G71-0
COMPONENT SIDE ● 79D02965G73-0
SOLDER SIDE ● 79D02965G74-0

FLN4649A MRTU Basic Module Main Board
Printed Circuit Board Detail
Component Side
November, 1988



SHOWN FROM SOLDER SIDE

OVERLAY ● 79D02965G72-0
COMPONENT SIDE ● 79D02965G73-0
SOLDER SIDE ● 79D02965G74-0

FLN4649A MRTU Basic Module Main Board
Printed Circuit Board Detail
Solder Side
November, 1988

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POWER SUPPLY CHARGER

GENERAL DESCRIPTION

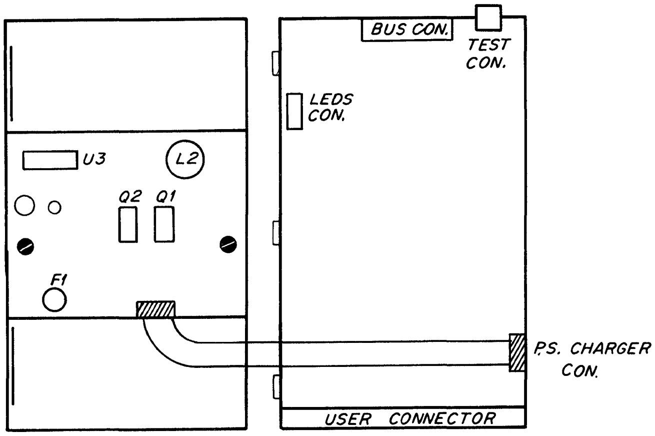
The FLN4847A Power Supply and Charger is a printed circuit board located inside the left panel of the MRTU Basic Module and the AMRTU module. A 14-pin flat cable connects the Power Supply and Charger to the MRTU Basic module.

The FLN4847A Power Supply and Charger provides the current to charge the HT440 radio, the Ni-Cad battery, and enables operation from an ac line with an external transformer.

The output voltage is regulated by an integrated circuit and ensures a short circuit by limiting internal current.

The charger supplies 65 mA maximum current for a Ni-Cad battery charging at normal temperature, and limits the current to a maximum of 25 mA at low temperature (-30°C) for conserving battery life.

For the AMRTU, which operates from a -24 Vdc (positive ground) supply, the Power Supply and Charger regulates the input voltage to 15 Vdc (requires insertion of jumper JU1).



69A02965G51-0

Power Supply Charger Connection

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technical writing services
1301 E. Algonquin Road, Schaumburg, IL 60196

POWER SUPPLY CHARGER FLN4847

PERFORMANCE SPECIFICATIONS

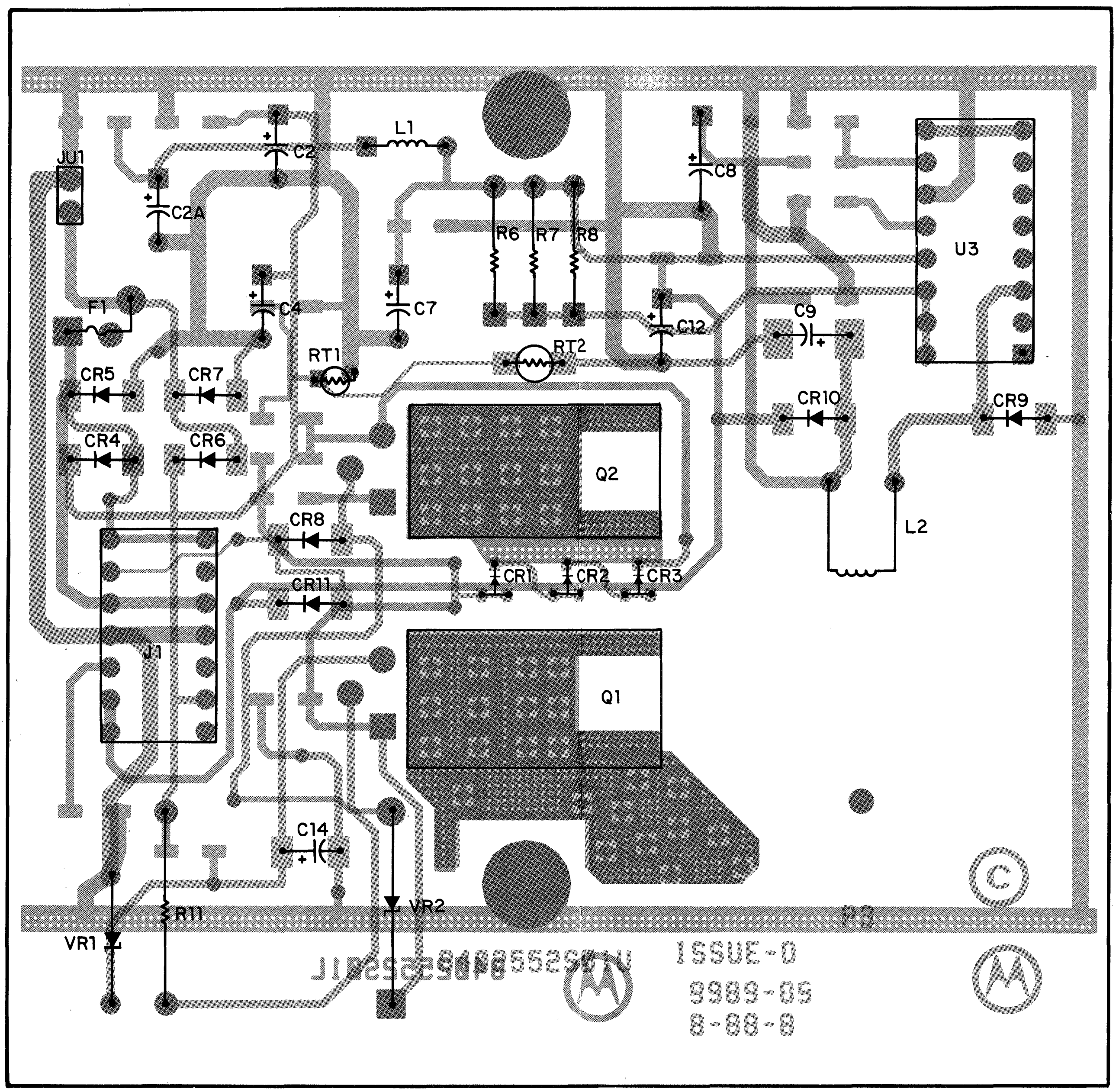
Input Voltage	22-38 Vdc, 22-28 Vac
Output	300 mA max, 14.8-15.1 Vdc
Output Voltage Ripple	200 mV peak-to-peak max at 300 mA
Operating Temperature	-30°C to +60°C
Fuse	F1=2A, normal blow on PCB mounting
Line Regulation	0.2%
Load Regulation	0.2%
Battery Charger	70 mA max at 25°C-60°C; 25 mA at -30°C
Overload Protection	Automatic electronic current limiting circuit, limits the output current
External Transformer	When using external transformer, ac range is 187 V - 265 V for 220/24 Vac; 95 V - 130 V for 110/24 Vac.

parts list

FLN4847A Switching Power Supply and Charger PL-0929-O

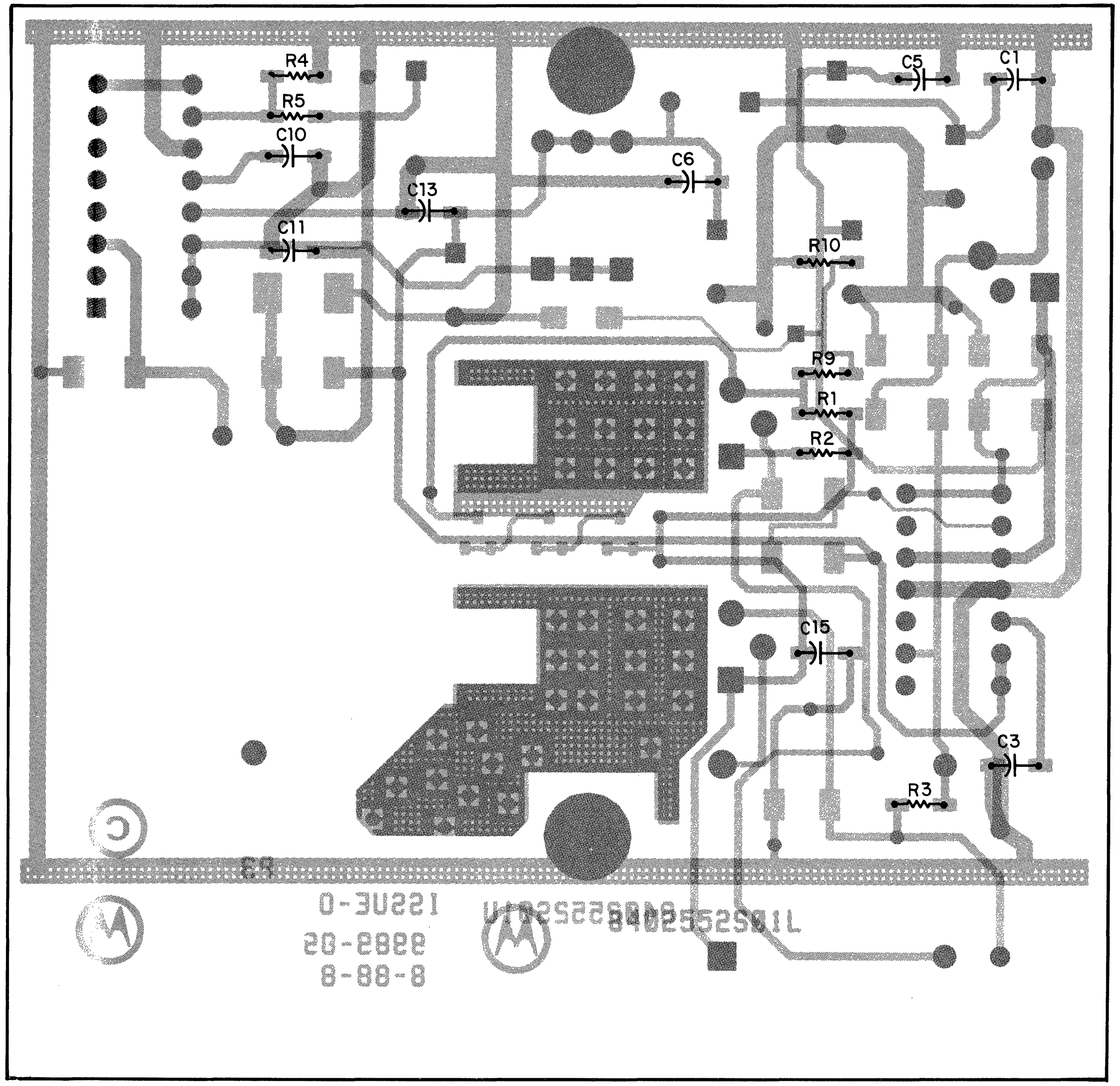
Reference Symbol	Motorola Part No.	Description
		Capacitor
C1	21-13741B69	0.1 uF; ±10% 50V chip
C2, C2A	23-02166L06	100 uF; 50V 20% radial
C3	21-13741B69	0.1 uF; ±10% 50V chip
C4	23-02166L06	100 uF; 50V 20%
C5, C6	21-13741B69	0.1 uF; ±10%; 50V
C7	23-02166L06	100 uF; 50V; 20%
C8	23-02166L02	1000 uF; 25V; 20%
C9	23-08857K09	10 uF; 25V chip
C10	21-13740B76	1.5 nF; 50V; NPO 5%
C11	21-13741B69	0.1 uF; ±10%; 50V
C12	23-02166L06	100 uF; 50V; 20%
C13	21-13741B69	0.1 uF; ±10%; 50V
C14	23-11066A06	1 uF; 35V; 20% chip
C15	21-13741B69	0.1 uF; ±10%; 50V
		Diode
CR1 thru CR3	48-11058B11	MMBD6050 SOT
CR4 thru CR7	48-82960R02	GL41B chip
CR8 thru CR10	48-02163L04	Schotky diode chip
CR11	48-82960R02	GL41B chip
		Fuse
F1	65-02126L04	2 A; 125 V
		Connector
J1	28-02415H03	14-pin conn. for flat cable part of flat cable: 30-08274C06F005
		Jumper
JU1	28-80141H04	2-pin jumper
		Coil
L1	24-08050H11	30 uH
L2	24-08050H01	1.5 mH
		Transistor (see note)
Q1	48-02089C14	TIP41C, NPN
Q2	48-00869647	M9647, PNP
		Resistor
R1	06-11077A78	1.5k; 5% chip
R2	06-11077A32	18 ohm; 5% chip
R3	06-11077A90	4.7k; 5% chip
R4	06-11077F32	2.43k; 1% chip
R5	06-11077G34	27.4k; 1% chip
R6 thru R8	06-80036G25	1 ohm; 5% axial; 1/4 W
R9	06-11077F70	6.04k; 1% chip
R10	06-11077B18	62k; 5% chip
R11	06-11045A15	39 ohm; 5%; 1/2 W
		Thermistor
RT2	06-02578S01	2k; thermistor chip
		Integrated Circuit (see note)
U1, U2	----	Not used
U3	51-02162C91	UA78940 universal dc to dc controller
		Zener Diode
VR1	48-02064C85	1N4707; 20V, low current
VR2	48-02064C27	1N5346B; 9.1V, axial
	Non Referenced Items	
	84-02552S01	printed circuit board
	29-02219K01	Term jumper
	42-10217A02	Strap tie
	03-00120621	Screws, 4-40x1/4
	09-02417H01	vertical fuse holder

Note: For optimum performance diodes, transistors and integrated circuits must be ordered by Motorola part numbers.



SHOWN FROM COMPONENT SIDE

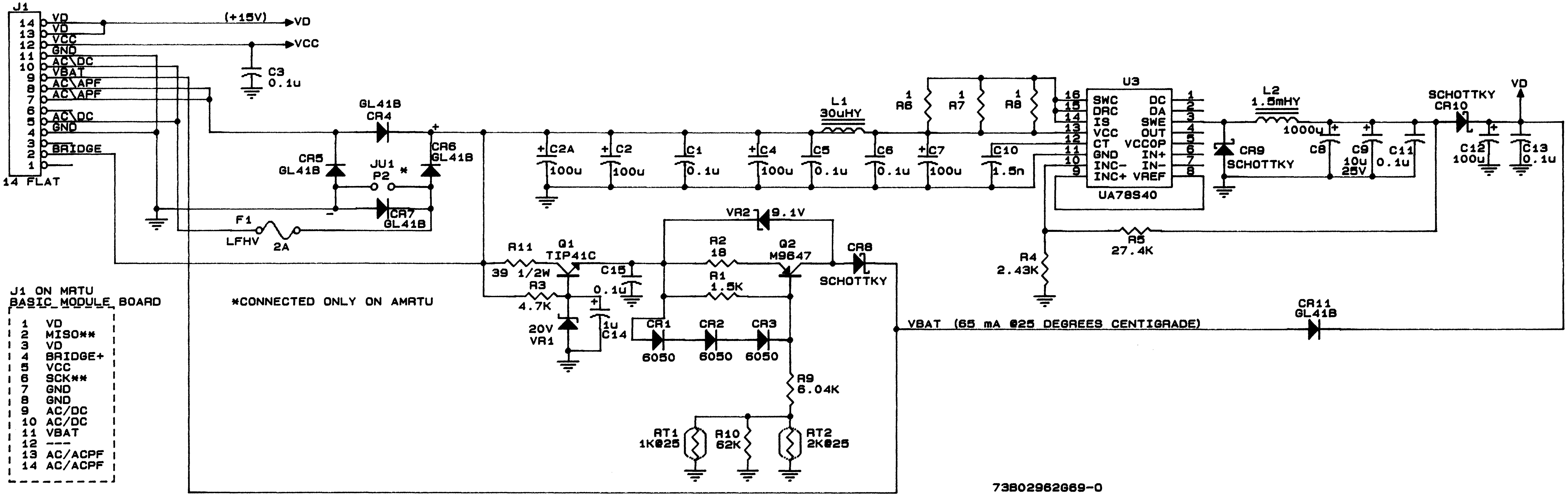
OVERLAY ● 79C02966G35-0
COMPONENT SIDE ● 79C02966G37-0
SOLDER SIDE ● 79C02966G38-0



SHOWN FROM SOLDER SIDE

OVERLAY ● 79C02966G36-0
COMPONENT SIDE ● 79C02966G37-0
SOLDER SIDE ● 79C02966G38-0

FLN4847A Power Supply Charger Board
Printed Circuit Board Detail
November, 1988



FLN4847A Power Supply Charger Board
Schematic Diagram
November, 1988

MOTOROLA INC.
Communications
Sector

DUAL POWER SUPPLY

1. GENERAL

The MRTU Dual Power Supply module (DPS or PS-8) provides the necessary operating power to MRTU PLUS models.

The DPS module provides the link between the battery, ac power, MRTU PLUS and radio dc power supply.

The DPS module includes the following components:

- AC Filter with Fuse (FLN4608)
- DC Power Supply (FLN4606)
- Battery Control Board (FLN4607).

2. FUNCTIONAL DESCRIPTION

The DPS module enables true power supply operation of the MRTU PLUS with a radio of up to 25W with 6A maximum drain. It allows the radio to go into transmission for up to 30 seconds and pause for at least 30s before retransmission.

A lead acid battery provides backup operation of the MRTU PLUS during ac power fail.

The battery control board supplies the battery charging current during normal operation (constant voltage charger). It disconnects the battery, when the battery voltage goes below 10.4 V (after extensive operation during an ac power fail condition).

After ac power-up, the battery is charged automatically when voltage reaches 12.7 V and connects the MRTU (if it was disconnected during a long ac power fail condition).

The DPS module includes the following optional feature.

About 1 minute before disconnecting the battery, a LOW BATTERY (LB) signal may be enabled to inform the central station that a low battery condition has occurred. At the same time, the central station can override (for about 1 minute) the switch that disconnects the battery on the control board with a SET signal thus providing time to perform urgent final operations.

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2.1 INPUTS

115/230 V ac with surge protection and noise suppression.

SET control signal, to override the switch on the battery control board (a closed contact to GND), keeps the relay in a set condition not allowing disconnection of battery.

2.2 OUTPUTS

15 V/7 A* dc for the MRTU including the radio.

Battery charging current (protected with a 10 A fuse against short circuiting of the battery).

AC power on LED indication.

AC power fail (PF) signal indication ("0" logic during ac power fail).

Low battery (LB) signal indication (steady state LB battery condition, open-drain, closed during LB condition).

* 7 A maximum, limited to 30s, the voltage increases linearily with temperature up to 16.6 V @ -30°C to meet battery charging specifications.

3. THEORY OF OPERATION

3.1 GENERAL

(Refer to the schematic diagram)

The battery control board performs several functions:

- Battery Charge and Discharge Control
- Surge Protection
- Power On Indication
- Set Function
- Low Battery Power Indication

3.2 BATTERY CONTROL

The battery control circuit controls the charging and discharging of the battery.

The circuit includes a comparator (R2, R3, U2, R4, R7, R8, Q2, R9) with hysteresis (R6). The function of the comparator is to compare the battery voltage (V3) with accurate voltage reference (U2). If the battery goes low in reference to a specific voltage, the drain of Q2 goes low; if the battery goes high in reference to a specific voltage, the drain of Q2 goes high.

The output of the comparator (Q2 drain) is connected to the logic circuitry that controls the switch (relay K1). When the battery goes low the comparator output goes low; U1a-3 goes high after about 5 seconds (R10, C8, C9) and Q5 outputs a low battery (LB) signal so as to indicate the intent to disconnect the battery (optional). After approximately 60 seconds (based on the time constant of R11, C13), Q4 is driven so that its drain goes low and resets the relay (to disconnect the battery).

When the battery goes high, the comparator goes high, U1d-11 goes low which causes the switch (relay K1) to set (to connect the battery).

The battery is charged through one of the following two procedures:

a. When the battery has been discharged to a level which causes the switch to disconnect and the ac supply is resumed, the battery is charged via CR2, R13.

b. The battery will remain in the charging position until the switch is connected; this will connect R14 in parallel with R13 and CR1 which will lower the serial resistance when the battery is being charged.

3.3 SURGE PROTECTION

Surge protection (VZ1, SG1) is provided between the ac line and GND. (The power supply includes varistor protection between ac line and ac neutral.)

3.4 POWER ON INDICATION

Power on indication is controlled by the power supply. If ac current is present, LED DS1 will light; if a power fail occurs, the power supply will enable Q1 to send a PF signal which is outputted via the User Connector.

3.5 SET FUNCTION

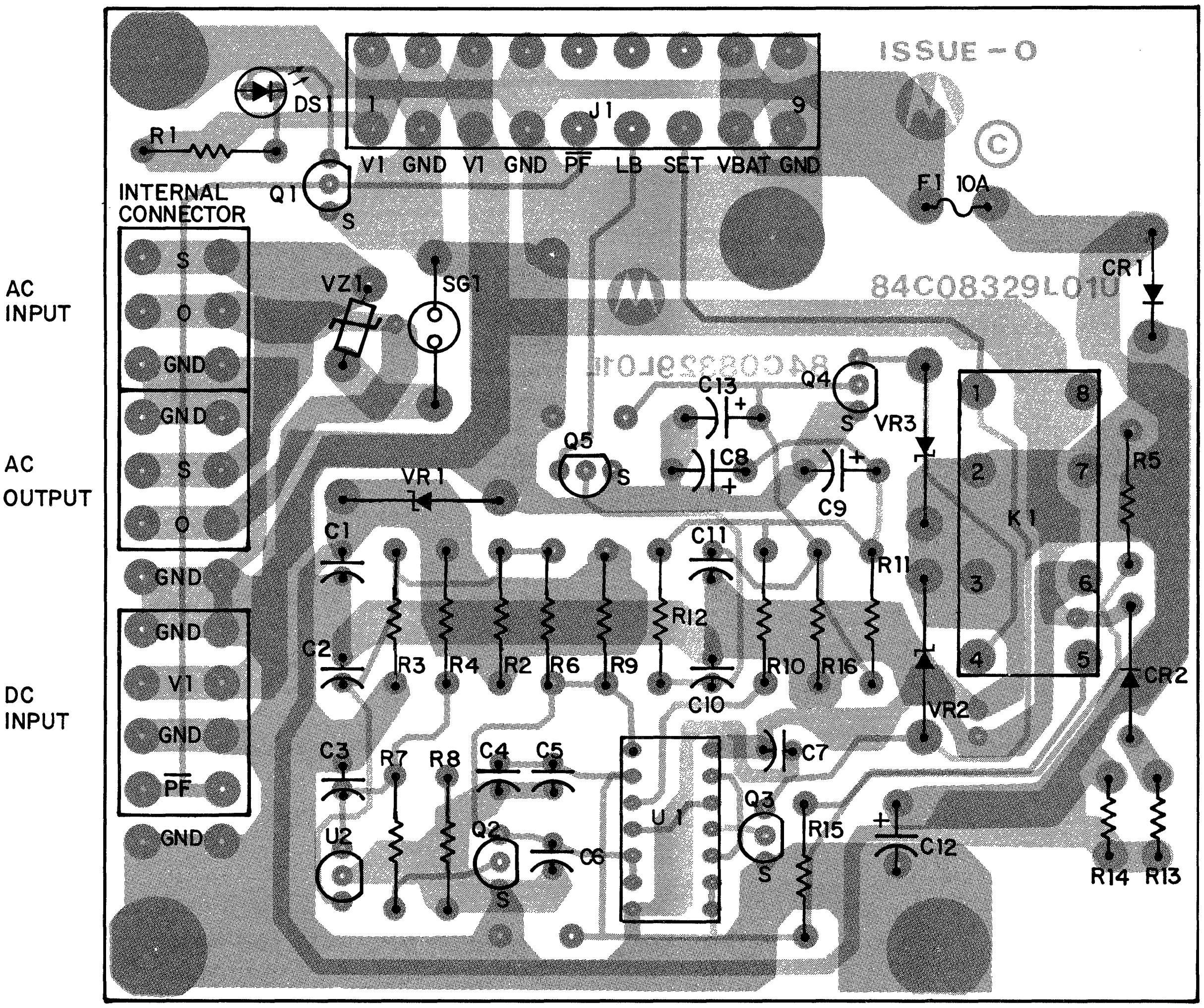
When the set function input from the user connector is shorted to GND, the battery disconnect function is disabled.

3.6 DISASSEMBLY

To access the power supply assembly, ac filter and battery control board proceed as follows:

Step 1. Unscrew the four captive screws on the top panel of the module.

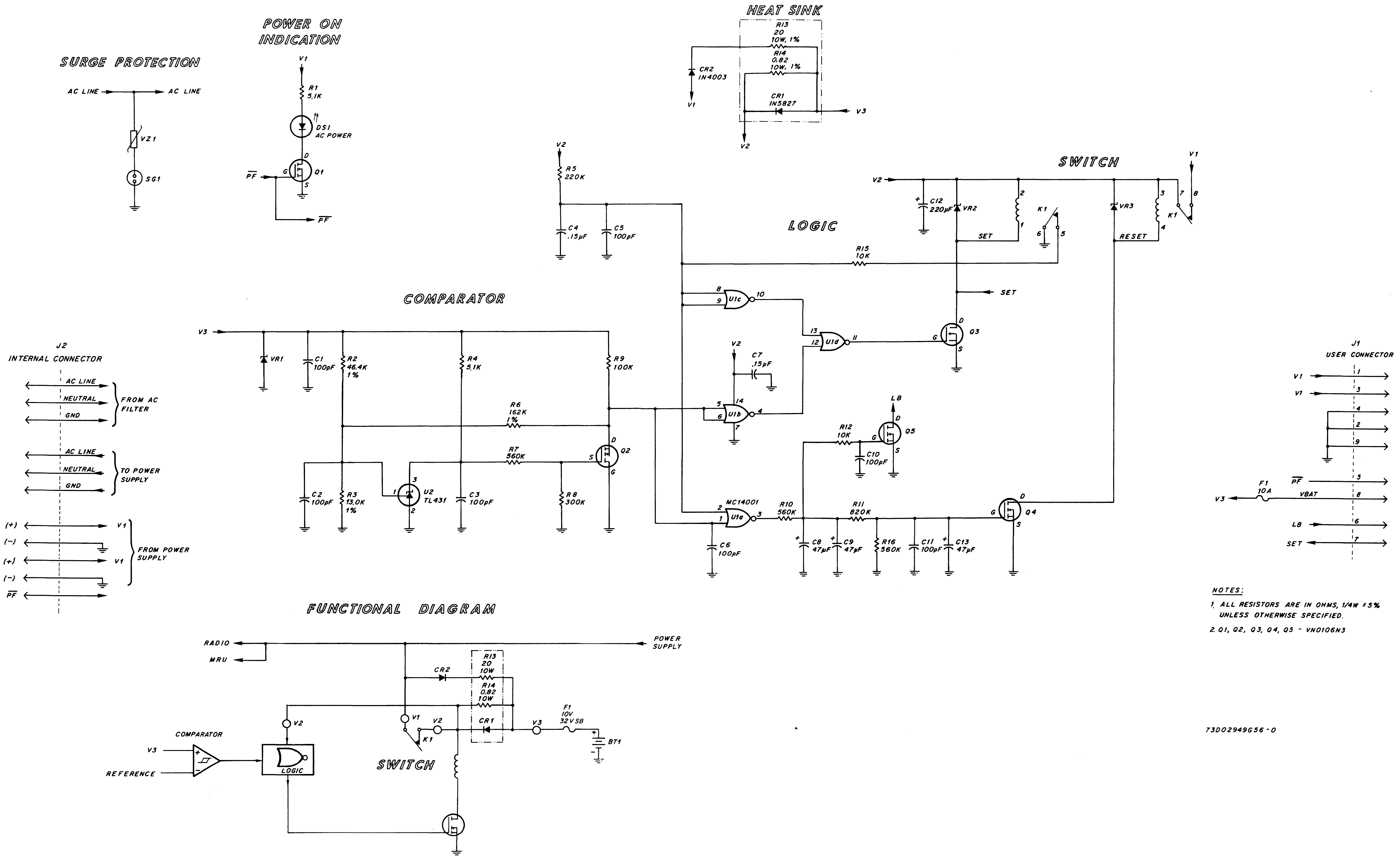
Step 2. Lift the panel; the power supply assembly and battery control board are now exposed.



SHOWN FROM COMPONENT SIDE

OVERLAY	●	79B02948G68-0
COMPONENT SIDE	●	79B02948G69-0
SOLDER SIDE	●	79B02948G70-0

FLN4607A Battery Control Board
Printed Circuit Board Detail
November, 1988



NOTES:

1. ALL RESISTORS ARE IN OHMS, 1/4W ±5% UNLESS OTHERWISE SPECIFIED.
2. Q1, Q2, Q3, Q4, Q5 - VN0106N3

FLN4607A Battery Control Board
Schematic Diagram
November, 1988

parts lists

FLN4607A Battery Control — PL-0556-O

Reference Symbol	Motorola Part No.	Description
		Capacitor
C1 thru C3	21-05455G01	100 pF
C4	21-84008H03	0.15 uF
C5, C6	21-05455G01	100 pF
C7	21-84008H03	0.15 uF
C8, C9	23-84538G06	47 uF 20%, 20 V
C10, C11	21-05455G01	100 pF
C12	23-08524G02	220 uF, 35 V
C13	23-84538G06	47 uF 20%, 20 V
		Diode
CR1	------	part of 01-02733G19
CR2	48-82466H13	rectifier H13
		LED
DS1	48-80159E09	red
		Connector
J1	31-02151C23	fed through TB contact; 9 used
		Relay
K1	80-02464C15	relay latch 9 V 8A
		Transistor
Q1 thru Q5	48-08237G05	VN0106
		Resistor
R1	06-11009C66	5.1k
R2	06-10621D56	46.4k, 1%
R3	06-10621D03	13k, 1%
R4	06-11009C66	5.1k
R5	06-11009D06	220k
R6	06-10621E09	162k, 1%
R7	06-11009D16	560k
R8	06-11009D09	300k
R9	06-11009C97	100k
R10	06-11009D16	560k
R11	06-11009D20	820k
R12	06-11009C73	10k 5% 1/4W
R13, R14	-----	part of 01-02733G19
R15	06-11009C73	10k 5% 1/4W
R16	06-11009D16	560k
		Spark Gap
SG1	80-83029H03	90 V
		Integrated Circuit
U1	51-02208C12	MC14001
U2	51-83222M81	TL431
		Zener Diode
VR1 thru VR3	48-02064C77	1N5353B
		Varistor
VZ1	06-02597K15	V230LA20A
	01-02733G19	Bracket assembly includes:
CR1	48-02216K06	Diode IN5827
F1	65-00834619	10 A 32 V SB for batt.
	09-82083C01	fuse holder for batt.
R13	17-02650H04	20 ohm 10 W 1%
R14	17-02650H01	0.82 ohm 10 W 1%
	01-02733G57	ac in cable assembly includes:
	39-10184A60	lug for filter; 3 used
	42-10217A27	penduit; 3 used
	01-02733G58	ac out cable assembly includes:
	15-02153L02	4-pin connector
	29-02213C09	pin for connector; 3 used
	42-10217A27	penduit; 3 used
	01-02733G59	dc out cable assembly includes:
	15-02153L03	5-pin connector
	29-02213C09	pin for connector; 5 used
	42-10217A27	penduit; 3 used
	Non-Referenced Items	
	07-08611L01	bracket
	03-00129997	screws for bracket; 2 used
	14-02453C01	MICA washer; 2 used
	43-02454C01	teflon bush
	04-02440C10	flat steel washer
	29-02455C01	terminal board
	04-02439C10	steel lock washer
	02-02438C10	hex nut
	03-02432C05	screw 2-56; 4 used
	04-02440C01	flat washer #2; 4 used
	04-02439C01	washer #2; 4 used
	02-02438C01	nut 2-56; 4 used
	84-08303L01	Printed circuit board

FLN4604A Chassis Base — PL-0557-O

Reference Symbol	Motorola Part No.	Description
	27-08623L01	chassis base

FLN4605A Label Kit — PL-0558-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	54-02443L01	label
	54-02533L01	wiring label
	54-08779L01	model label
	54-08826L01	template

Note: For optimum performance, diodes, transistors and integrated circuits must be ordered by Motorola part numbers.

FLN4815A Label Kit — PL-0618-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	54-02443L01	label
	54-02094K01	label
	54-02533L01	wiring label
	54-08779L01	model label
	54-83607H01	frequency label
	54-08826L01	template

FLN4816A Label Kit — PL-0619-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	54-02443L01	label
	54-02633K01	FCC432 label
	54-02533L01	wiring label
	54-08779L01	model label
	54-83607H01	frequency label
	54-08826L01	template

FLN4817A Label Kit — PL-0620-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	54-02443L01	label
	54-02533L01	wiring label
	54-08779L01	model label
	54-08826L01	template

FLN4606A DC Power Supply — PL-0559-O

Reference Symbol	Motorola Part No.	Description
	10-102246H16	Power Supply LVS-45E-15-41335 LAMBDA

FLN4608A AC Filter — PL-0560-O

Reference Symbol	Motorola Part No.	Description
	Non-Referenced Items	
	09-02388L02	fuse holder insert for 5x20mm
	09-02389L02	ac filter
	28-08273C04	plug power angled 250V 10A
	65-00061688	fuse, 4 A 250V

FLN4609A Hardware and Box — PL-0561-O

Reference Symbol	Motorola Part No.	Description
	Non-Referenced Items	
	01-02733G21	chassis bracket assembly
	01-02733G22	cover bracket assembly
	03-02443C45	screws for cover & chassis; 8 used
	42-83123F01	retainer; 4 used
	04-02439C19	lock-washer #6 black; 8 used
	04-02440C15	flat washer #6; 4 used
	03-10906A14	screw for PS; 2 used
	01-02734G78	wiring assembly
	03-00129997	lock, screw assembly 4-40x5/16"; 4 used

FLN4632A Hardware for 10 Ah Battery — PL-0562-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	01-02735G94	wire and pin assy
	03-00136657	screw, 1/4x20-5/8"; 2 used
	03-02443C67	screw, 8-32x1/2"; 4 used
	04-00136658	lock washer 1/4"; 2 used
	04-02439C18	washer; 4 used
	04-02440C16	flat washer 170x3/8x.032; 4 used
	04-02440C28	flat washer
	07-08613L01	battery cover
	07-08615L01	battery brackets
	07-08654L01	battery brackets
	39-10184A60	contact receptacle; 4 used
	75-08616L02	rubber for cover

FLN4666A 5 Ah Battery — PL-0563-O

Reference Symbol	Motorola Part No.	Description
BT1	60-02591K16	lead acid battery

Note: For optimum performance, diodes, transistors and integrated circuits must be ordered by Motorola part numbers.

FLN4603A Hardware for 5 Ah Battery — PL-0564-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	07-08612L01	battery brackets; 2 used
	07-08613L01	battery cover
	03-00136657	screw, 1/4 x 20-5/8"; 2 used
	04-00136658	lock washer, 1/4"
	04-02440C28	flat washer; 2 used
	75-08616L02	rubber for cover
	03-02443C67	screw, 8-32 x 1/2"; 4 used
	04-02439C18	washer; 4 used
	04-02440C16	flat washer 170 x 3/8 .032"; 4 used
	39-10184A60	contact receptacle; 2 used
	42-10217A27	penduit; 3 used

Note: For optimum performance, diodes, transistors and integrated circuits must be ordered by Motorola part numbers.

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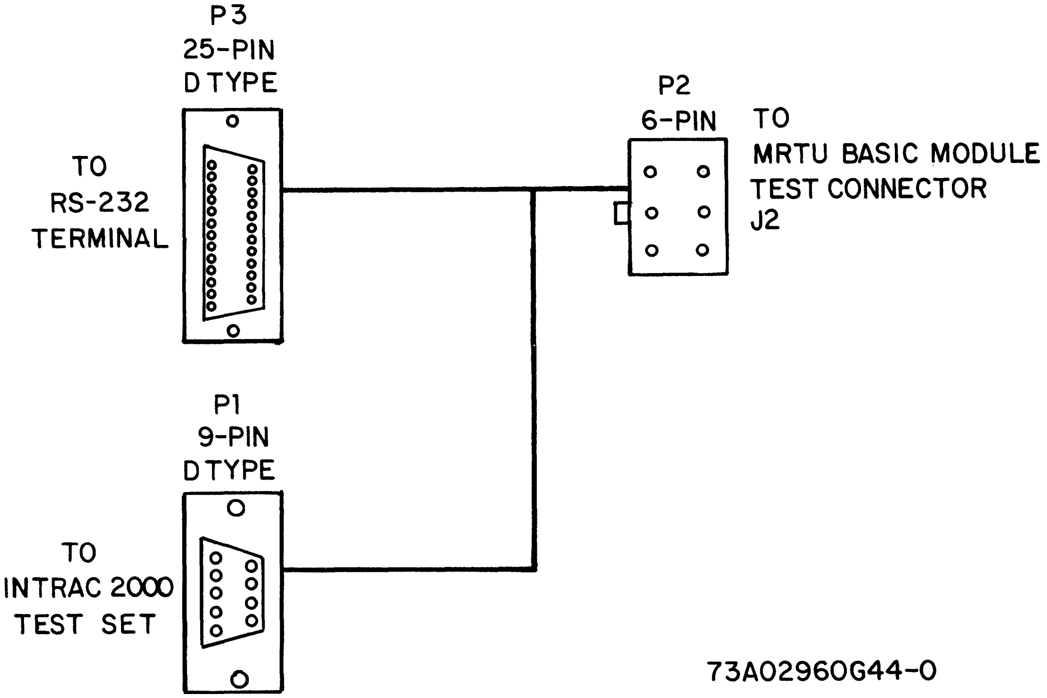
TEST CABLE

FKN5780A

DESCRIPTION

The FKN5780 Test Cable connnects the MRTU Basic Module to the INTRAC 2000 Test Set and to an RS-232 port (of a terminal or personal computer) for parameter configuration in the field.

See the figure below for correct test cable connection to: Test Set, MRTU Basic Module and RS-232 port (of terminal).



Test Cable Connection

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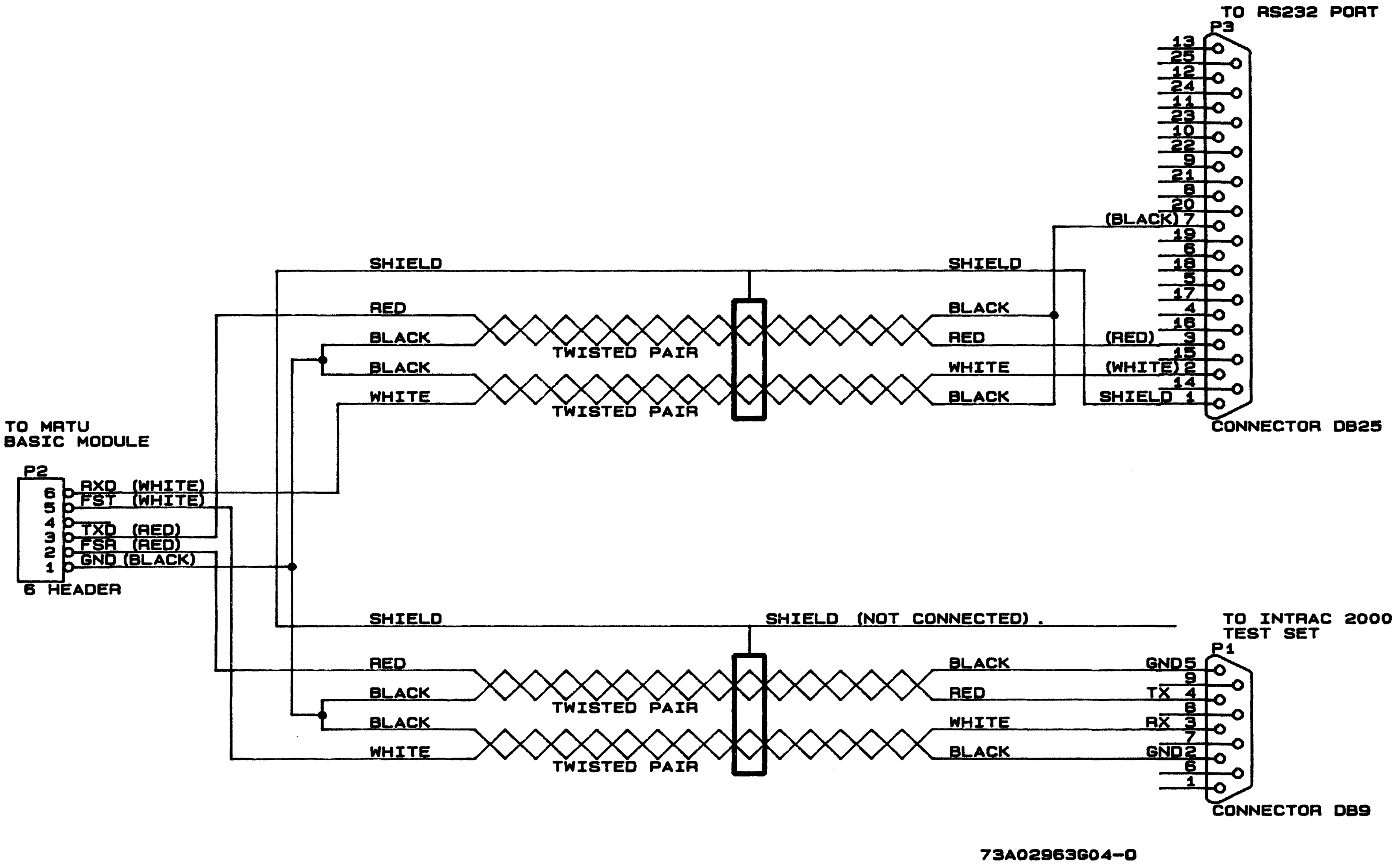
parts list

FKN5780A Test Cable for MRTU Basic Module **PL0931-O**

Reference Symbol	Motorola Part No.	Description
		Connector
P1	09-02223C01	9-pin D type
P2	15-08236G03	conn. housing
P3	09-84538E03	25-pin recp.
	Non Referenced Item	
	15-02221C01	shell
	29-08551C01	terminal; 6 used
	30-08566C07	cable, shielded; 2 used
	3700132526	tubing; 8 used
	37-00127829	tubing
	37-00134371	tubing
	37-00134389	tubing; 2 used
	37-00135566	tubing
	37-02413C04	shrinkable tube; 2 used
	42-02146C02	shell clip
	42-10217A02	strap tie .091x3.62
	54-02451S01	label



FKN5780A Test Cable for MRTU Basic Module
Schematic Diagram
November, 1988

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DOWNLOAD CABLE

Model FKN5807A

1. GENERAL DESCRIPTION

The MRTU Basic Module download cable enables field parameter changes in remote MRTU Basic Modules via another MRTU Basic Module.

2. FUNCTIONAL DESCRIPTION

(Refer to Figure below)

Prepare the parameter changes and download them onto a MRTU Basic Module in the laboratory (MRTU #1). Upon arrival at the remote site, download the parameters stored in MRTU #1 onto the field MRTU Basic Module (MRTU #2) as follows:

Step 1. Connect power to both modules.

Step 2. Insert the connectors (they are reversible) into the test connector J2 of MRTU #1 and MRTU #2.

Step 3. Press the display test pushbutton (located on the latch door) of MRTU #1 for more than one second and the new parameters will be recorded within ten seconds in MRTU #2. The display LEDs (located on the latch door) of MRTU #2 will switch on momentarily during recording.

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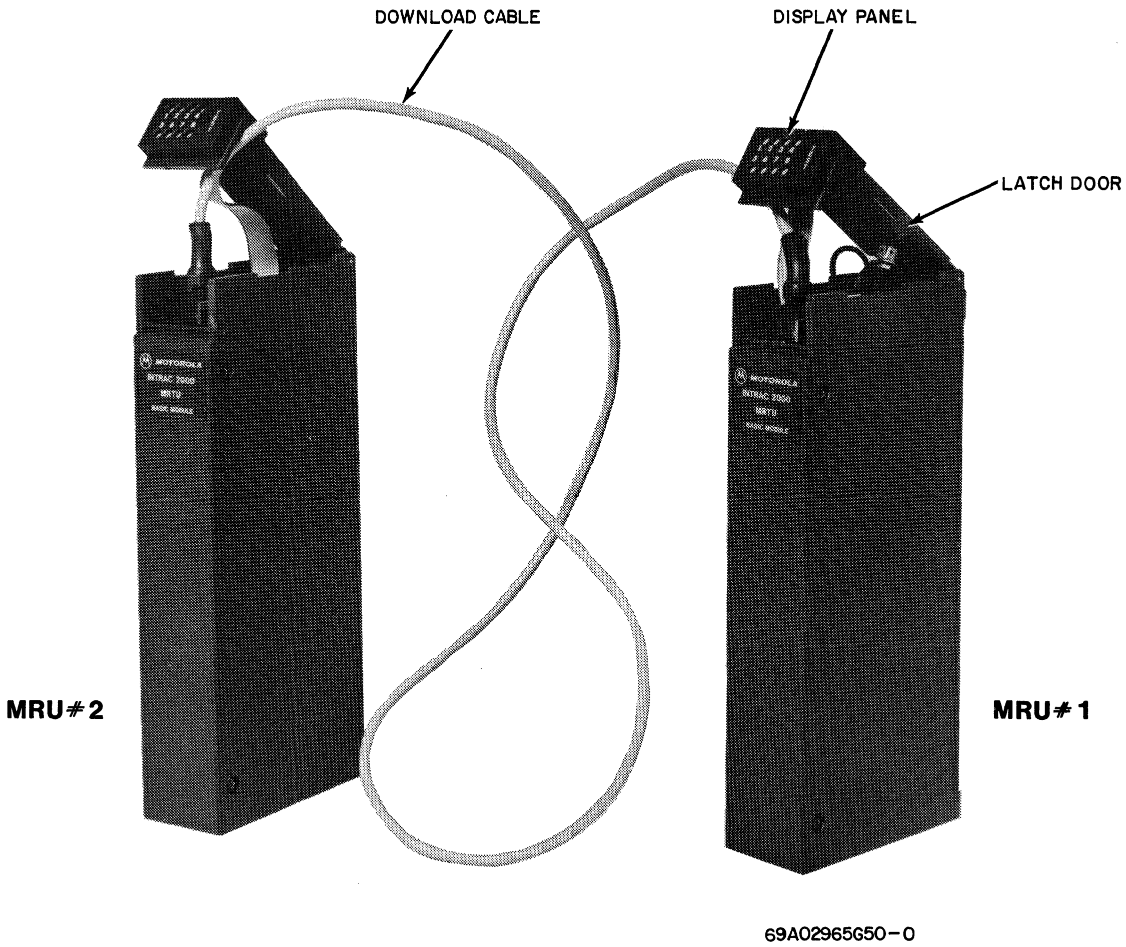
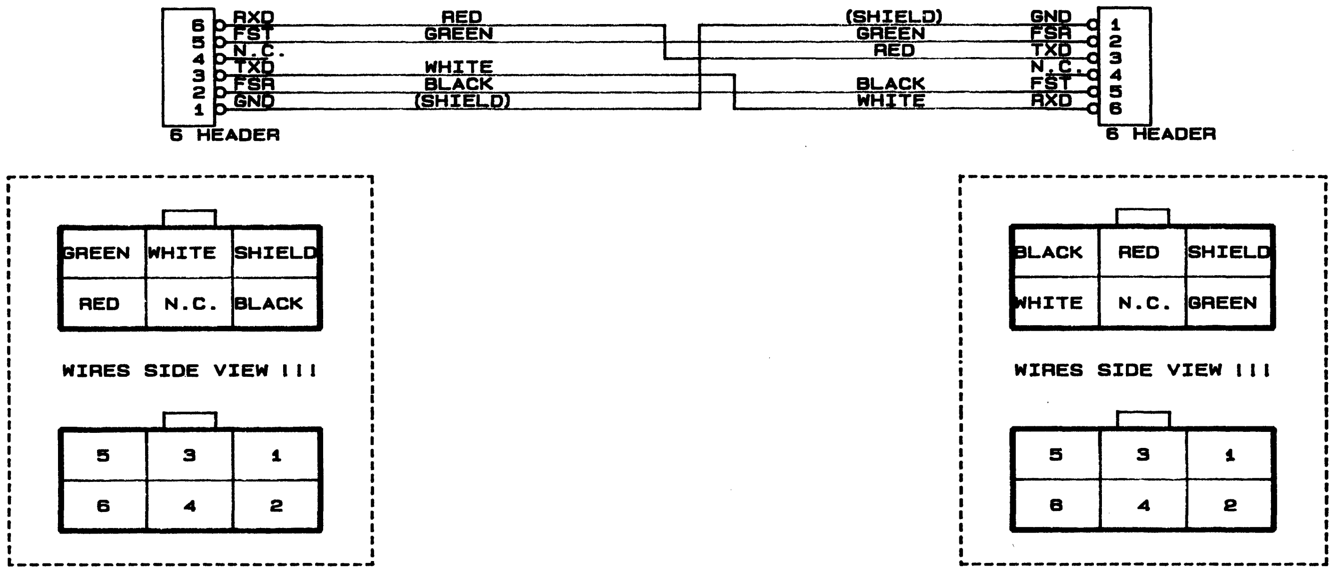


Cable Connection of Two MRTU Basic Modules.

parts list

FKN5807A Download Cable for MRTU Basic Module PL0933-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Item	
	30-02342C03	cable 4-wires shielded
	29-08551C01	term. for plug; 10 used
	37-02413C04	shrinkable tube; 2 used
	3700134389	shrinkable tube; 2 used
	37-00122063	teflon insulation; 2 used
	15-08236G03	6-pin header; 2 used



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FKN5807A Download Cable for MRTU Basic Module
Schematic Diagram
November, 1988

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RADIO INTERFACE

Model FLN4948A

1. GENERAL DESCRIPTION

The MRTU Radio Interface board enables connection of the MRTU Basic Module with various types of radios. The Radio Interface board is mounted on the radio chassis located on the door of the MRTU housing.

2. FUNCTIONAL DESCRIPTION

2.1 CONNECTORS

Four connectors (J1, J2, J3 and J4) are provided on the Radio Interface board; the function of each connector is provided in the following table.

Table 1. Connector Functions

Pin Connector	Signal Type	Connected To:
J1	Boxed header, 16-pin	Darcom/Mostar
J2	Screw type, 5-pins	Maxar/ any other Motorola radio
J3	Microphone jack, 8-pins	Maxtrac
J4	Boxed header, 14-pins	Basic Module

The pin assignment for connector J2 (for Maxar, MC Micro, other radios is as follows:

Pin 1 —— Transmitted FSK (FST)
Pin 2 —— Received FSK (FSR)
Pin 3 —— Push-To-Talk (PTT)
Pin 4 —— Channel Monitor (CM)
Pin 5 —— Ground (GND)

The FST level is adjusted by potentiometer R19 (depending on the radio type); to increase the FST level, turn R19 clockwise. The FST is factory adjusted to 3 kHz deviation.

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2.2 LEDS

Two indication LEDs are provided: red and green; they are located on the underside of the PC board. An arrow with PTT (red) or CM (green) on the top side of the PC board indicates their location.

LED Indications

RADIO	PTT (Green)		CM (Red)	
	On	Off	On	Off
Maxar	Transmit	Receive	Busy	Not busy
Maxtrac VHF/UHF	Transmit	Receive	Busy	Not busy
Maxtrac Trunked	Transmit	Receive	Channel granted	Channel not granted
Mostar	Transmit	Receive	Channel granted	Channel not granted
Darcom	Transmit	Receive	Busy	Not busy
MC Micro	Transmit	Receive	Not busy	Busy
Other Radios				
Busy = High	Transmit	Receive	Busy	Not busy
Busy = Low	Transmit	Receive	Not busy	Busy

2.3 FREQUENCY SELECTION FOR DARCOM RADIOS

Set S2 to the appropriate frequency and power up the unit.

2.4 SELECTION OF MOSTAR/DARCOM OR OTHER RADIOS

The Radio Interface PC board includes two sets of resistors; one for use with a MOSTAR radio, and one for use with DARCOM or other radios. The resistors for the MOSTAR radio and the DARCOM radio are clearly marked on the PC board (MOSTAR, DARCOM).

When the system uses a MOSTAR radio, the resistors marked DARCOM R7 to R15 must be cut. When the system uses a DARCOM radio or any other radio, or is a system less radio, the resistors marked MOSTAR Rl to R6 must be cut; this is done at factory. However, if the Radio Interface is ordered as an accessory, the appropriate resistors must be cut (in laboratory conditions) by the user before connecting the Radio Interface PC board to the system.

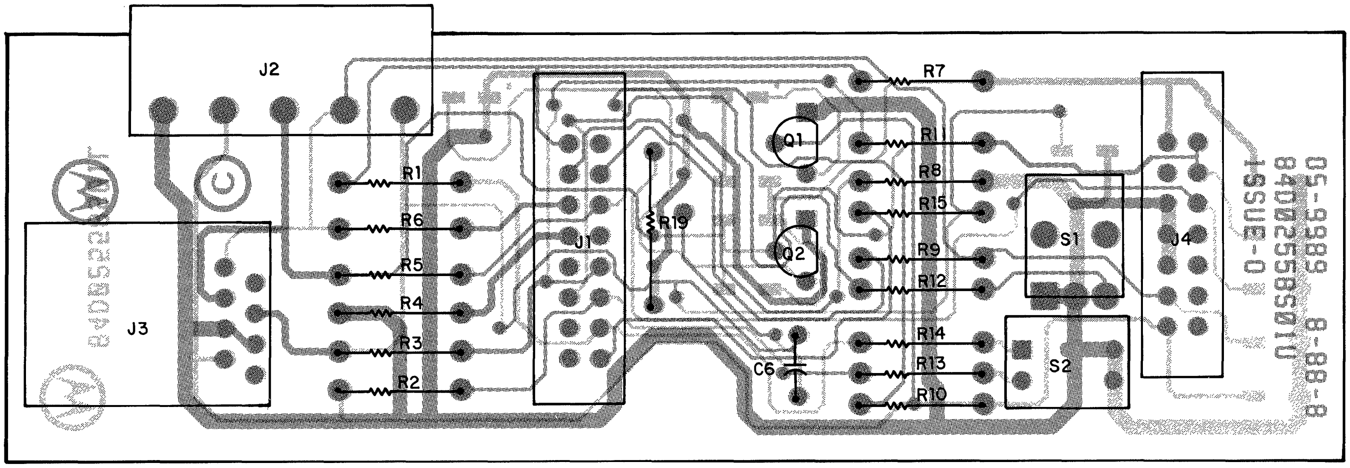
Note- For radios other than MOSTAR/DARCOM, the MOSTAR resistors should be cut to avoid signal collision.

parts lists

FLN4948A Radio Interface Board PL-0930-O

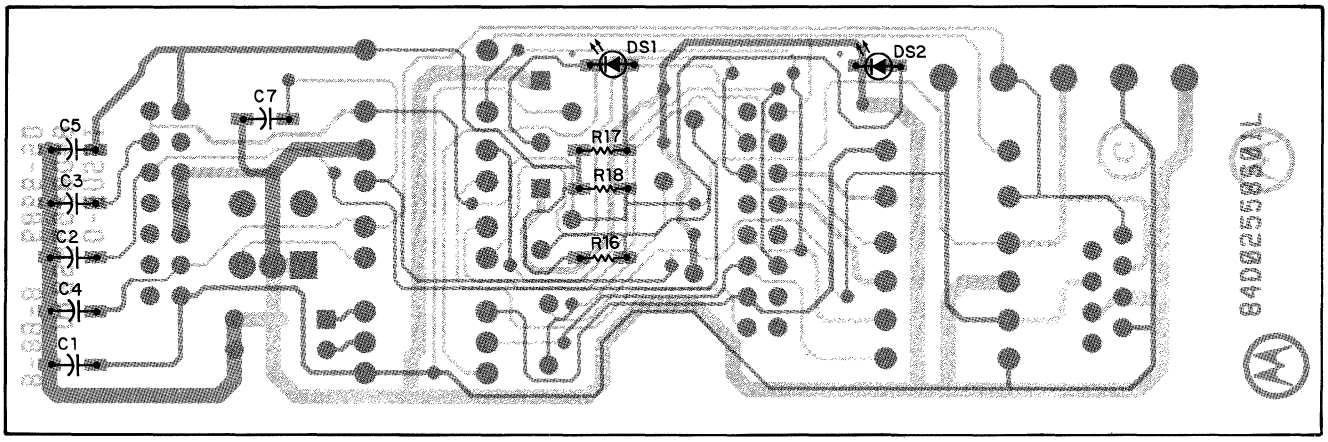
Reference Symbol	Motorola Part No.	Description
		Capacitor
C1 thru C5	21-11031A39	100 pF; 50 V chip
C6	21-08029H07	1 uF 50 V
C7	21-11031A39	100 pF; 50 V chip
		LED
DS1	48-02579S03	green LED chip
DS2	48-02579S02	red LED chip
		Connector
J1	28-08044H05	16-pin conn.
J2	28-08508G02	5-header conn. post
J3	09-80132M01	8-pin phone socket
J4	28-08044H01	14-pin connector
		Transistor (see note)
Q1, Q2	48-08237G05	VN106
		Resistor
R1 thru R12	06-11009D23	0 ohm jumper axial
R13, R14	06-11009C49	1k; 5% axial
R15	06-11009D23	0 ohm jumper axial
R16, R17	06-11077A78	1.5k; 5% chip
R18	06-11077B31	220k; 5% chip
R19	18-02467C03	5k ohm 0.75 W
		Switch
S1 R.A.	40-08242G04	momentary pushbutton (optional)
S2	40-02235C09	2 DIP switch
	Non Referenced Item	
	84-02558S01	printed circuit board
	31-08509G02	terminal with socket

Note: For optimum performance diodes, transistors and integrated circuits must be ordered by Motorola part numbers.



SHOWN FROM COMPONENT SIDE

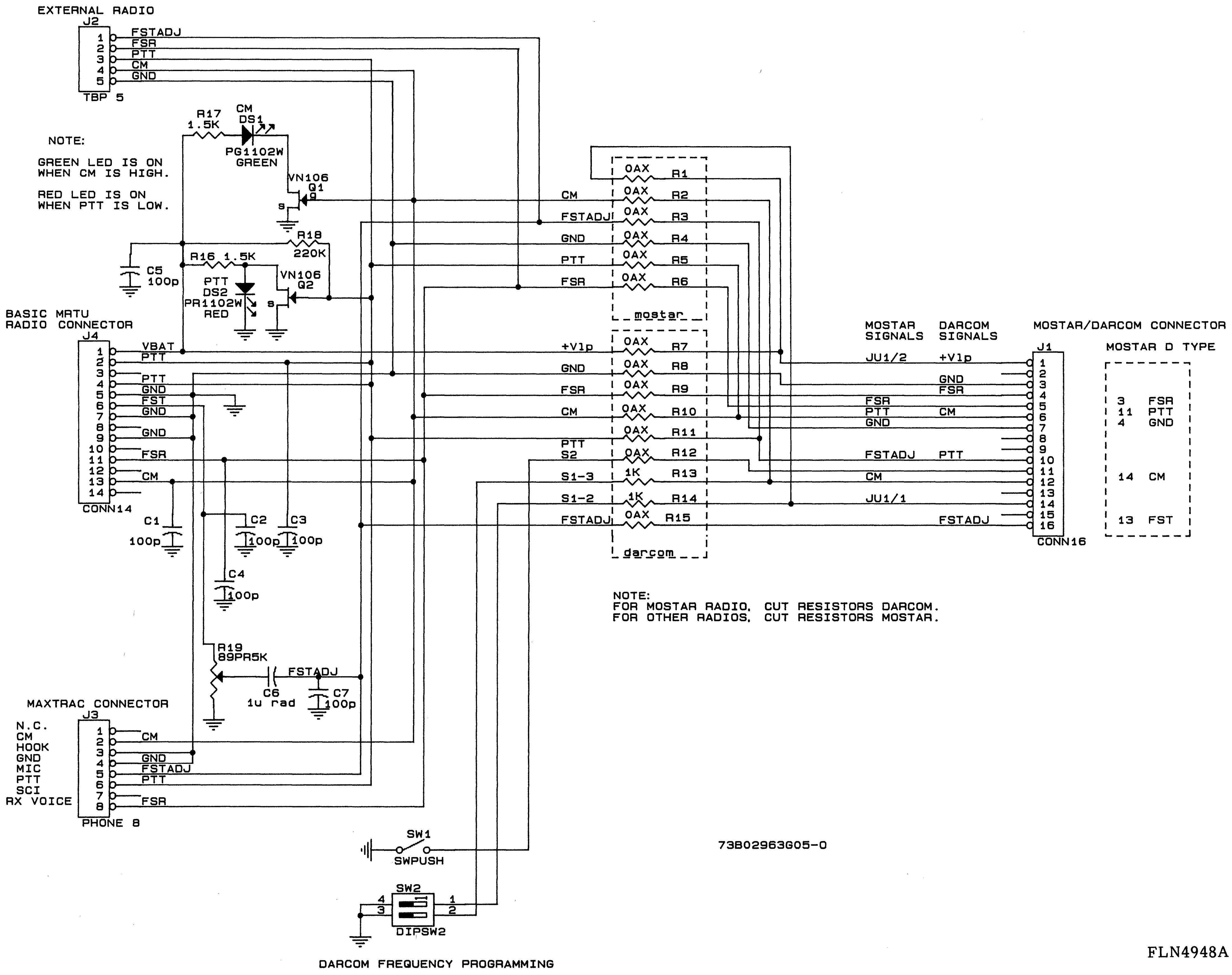
OVERLAY ● 79B02966G53-0
COMPONENT SIDE ▨ 79B02966G55-0
SOLDER SIDE ░ 79B02966G56-0



SHOWN FROM SOLDER SIDE

OVERLAY ● 79B02966G54-0
COMPONENT SIDE ░ 79B02966G55-0
SOLDER SIDE ▨ 79B02966G56-0

FLN4948A Radio Interface Board
Printed Circuit Board Detail
November, 1988



NOTE:

GREEN LED IS ON
WHEN CM IS HIGH.

RED LED IS ON
WHEN PTT IS LOW.

NOTE:
FOR MOSTAR RADIO, CUT RESISTORS DARCOM.
FOR OTHER RADIOS, CUT RESISTORS MOSTAR.

FLN4948A Radio Interface Board
Schematic Diagram
November, 1988

MOTOROLA INC.
Communications Sector

STATUS DISPLAY

1. GENERAL

The Status Display kit provides visual status indications on the MRTU basic module and on the MRTU SI-8 module. In addition, the Status Display kit provides diagnostic indications for the MRTU basic module.

Status and diagnostic indications are presented on a status display panel which is comprised of eight LED's and a Test pushbutton. Each LED indicates the physical status of a dry contact status input (for example, LED ON for a closed input; LED OFF for an open input). A photo of the display LED panel appears in Figure 1.

The Status Display kit is factory installed in the MRTU basic module and SI-8 module. When provided in the SI-8 module, the Status Display kit includes the LED panel, a status display board (SDB) and inter-connecting flat cable (refer to Figure 2). When provided with the MRTU basic module, the Status Display kit includes the LED panel and the appropriate inter-connecting flat cable.

2. OPERATION

The Test pushbutton on the LED panel is provided in order to test proper functioning of the LED's. Press the Test pushbutton to light up all LED's.

LED operation is as follows:

In the MRTU basic module, a LED is lit (ON) when the status input is closed; the LED is OFF when the status input is open.

In the SI-8 module, eight DIP-switches (S1-S8) on the SDB determine LED operation according to the following table:

Status Input # (1-8)	**DIP-S. #** (S1-S8)	**LED #** (DS1-DS8)
closed	closed	ON
closed	open	OFF
open	closed	OFF
open	open	ON

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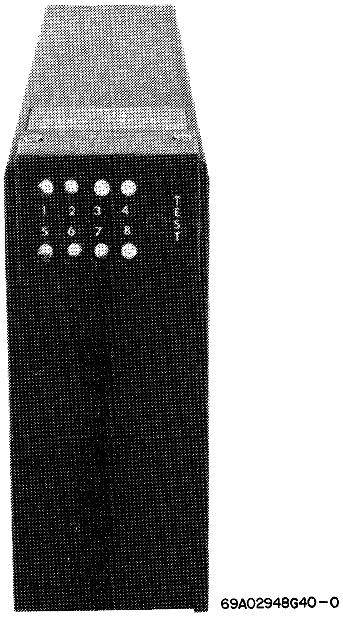


Figure 1. Display LED Panel

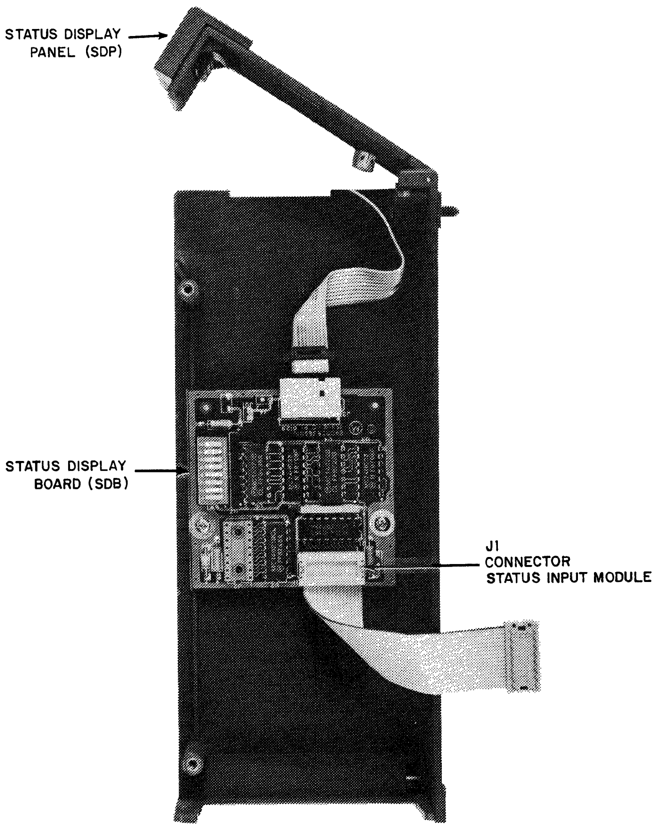

STATUS DISPLAY PANEL (SDP)
STATUS DISPLAY BOARD (SDB)
J1 CONNECTOR STATUS INPUT MODULE
69A02967G29-0

Figure 2. Status Display Board (SDB) and Inter-connecting Flat Cables (When used with the SI-8 Module)

3. THEORY OF OPERATION

Refer to the block diagram in Figure 3 and to the schematic diagram.

The Status Display kit includes all the necessary logic and drivers in order to light the LED's according to the physical status of each status input.

When the Status Display kit is part of the MRTU basic module, the LED control signals and logic are received by the LED panel directly from the basic module; the signals are provided via a flat cable connected between J5 (on basic module) and the LED panel.

When the Status Display kit is part of the SI-8 module, the status display board (SDB) provides the LED control signals to the LED panel. The status input signals are read from the SI-8 module via shift register U1 on the SDB, which is connected via a flat cable to the SI-8 module.

The logic on the SDB which lights the eight LED's is comprised of XOR gates (U4 and U6) and NOR gates (U3 and U5). Each LED is driven by the NOR gate output, which is limited by a 3.9 kohm resistor (R1-R8), according to the DIP-switch setting (S1-S8) and the status of input signals P1-P8.

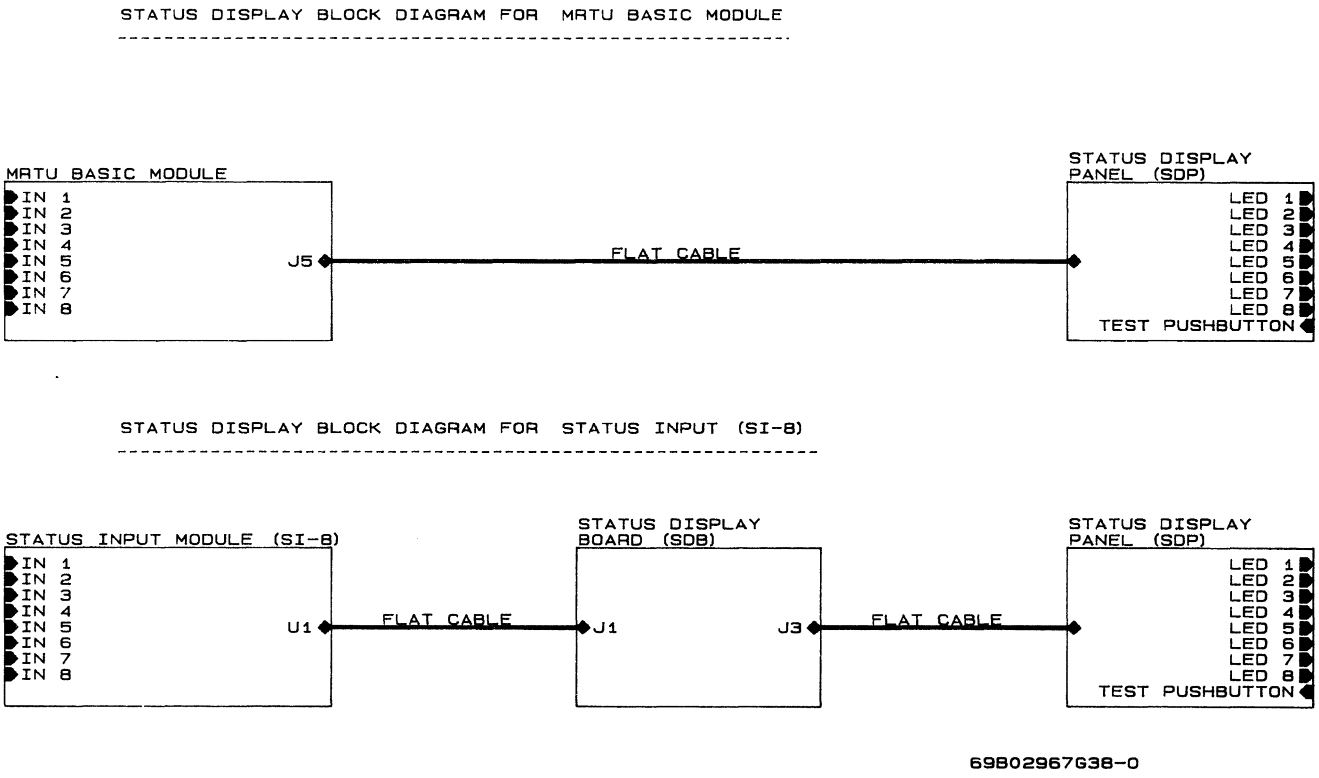
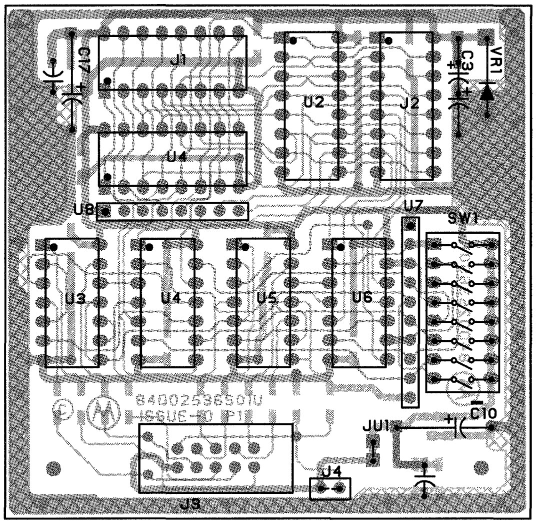
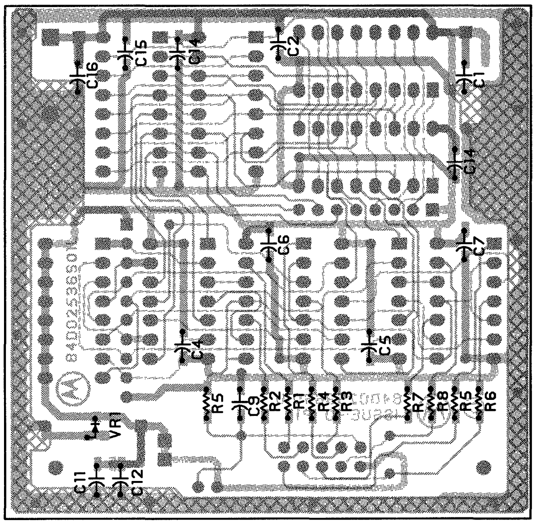


Figure 3. Functional Block Diagram



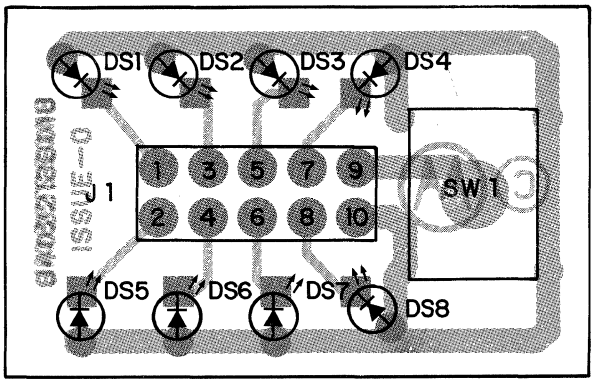
SHOWN FROM COMPONENT SIDE

OVERLAY	●	79A02948G22–A
COMPONENT SIDE	▨	79A02948G24–A
SOLDER SIDE	▨	79A02948G25–A



SHOWN FROM SOLDER SIDE

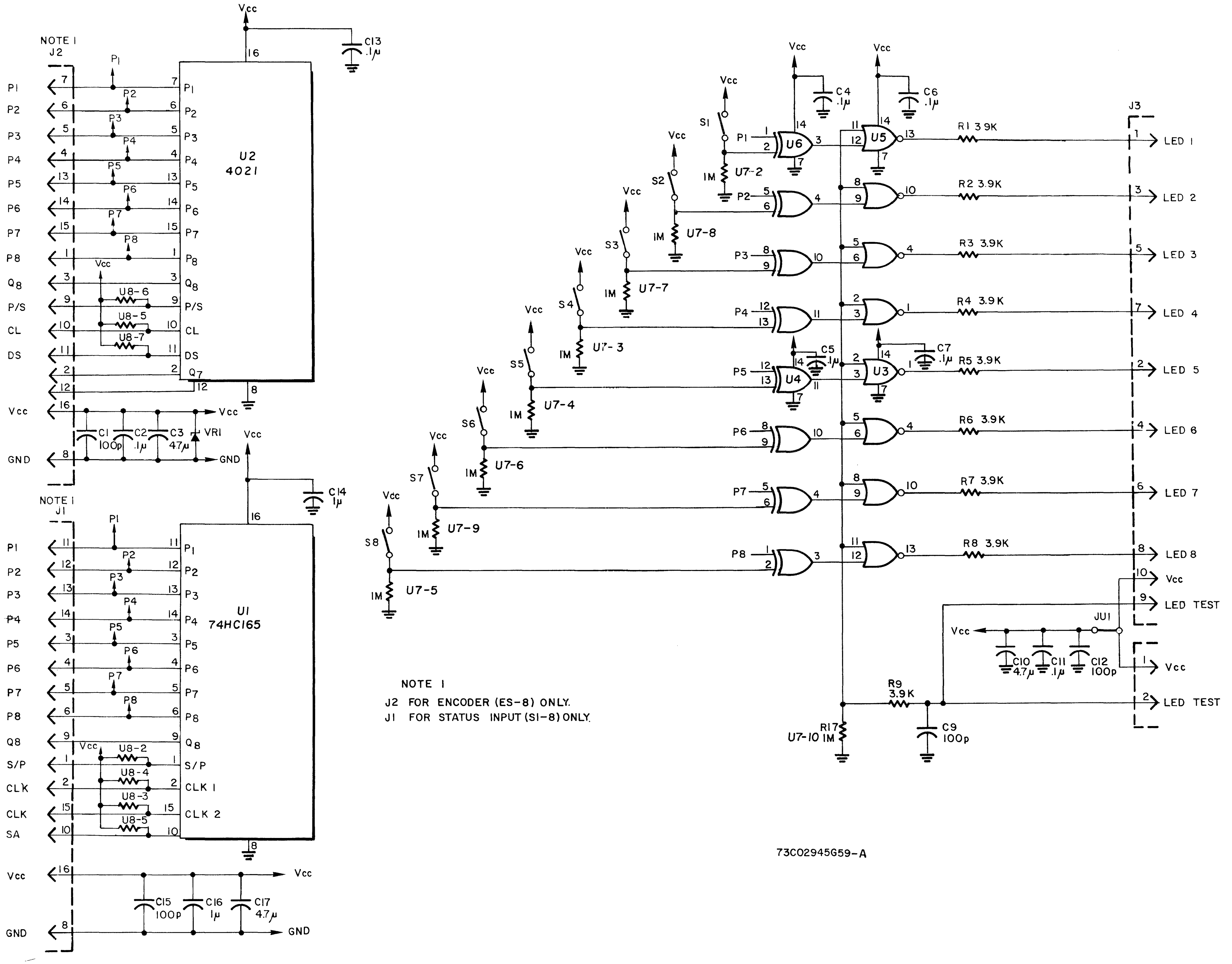
OVERLAY	●	79A02948G23– A
COMPONENT SIDE	▨	79A02948G24–A
SOLDER SIDE	▨	79A02948G25–A



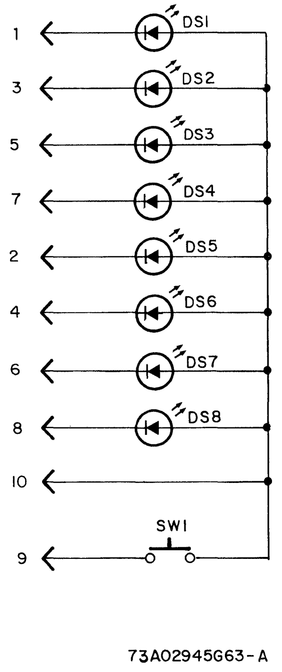
SHOWN FROM COMPONENT SIDE

OVERLAY	●	79A02948G26-A
COMPONENT SIDE	▨	79A02948G27-A
SOLDER SIDE	▨	79A02948G28 -A

FLN4626B Status Display Board
FLN4627B Status Display Panel
Printed Circuit Board Detail
November, 1988



STATUS DISPLAY BOARD



STATUS DISPLAY PANEL

FLN4626B Status Display Board
FLN4627B Status Display Panel
Schematic Diagram
November, 1988

parts list

FLN4626B Status Display Board **PL-0542-A**

Reference Symbol	Motorola Part No.	Description
		Capacitor
C1	21-11031A39	100 pF
C2	21-11032B13	0.1 uF
C3	23-84762H07	4.7 uF
C4-C7	21-11032B13	0.1 uF
C8	----	not used
C9	21-11031A39	100 pF
C10	23-84762H07	4.7 uF
C11	21-11032B13	0.1 uF
C12	21-11031A39	100 pF
C13,C14	21-11032B13	0.1 uF
C15	21-11031A39	100 pF
C16	21-11032B13	0.1 uF
C17	23-84762H07	4.7 uF
		Connector
J1,J2	09-02134C03	16-pin socket
J3	28-08044H12	10-pin connector
		Resistor
R1-R9	06-11024A63	3.9 k
		Integrated Circuit
U1	51-08244G53	MC74HC165
U2	51-02073C44	MC14021BCL
U3	51-08244G06	MC74HC02N
U4	51-02073C31	MC14070B
U5	51-08244G06	MC74HC02N
U6	51-02073C31	MC14070B
U7	51-02599K06	9 x 1 M SIP
U8	51-02599K13	7 x 220K SIP
		Zener Diode
VR1	48-82256C66	6.8 V, 1 W 5%
	Non-referenced Items	
	36-02140C13	polarizing key
	40-02235C01	8-position DIP switch
	84-02536S31	printed circuit board

FLN4627B Status Display Panel **PL-0860-O**

Reference Symbol	Motorola Part No.	Description
	Non-referenced items	
	98301314	LED cable assembly, includes:
	09-02136C09	10-pin connector, female
	28-08555H07	10-pin connector, male
	30-08274C01	flat cable
	07-02431C03	mounting
	15-02209K06	10-pin shell
	01-98301315	PC assembly includes:
	39-82036M01	switch, switch button
	48-05729G21	LED QLMP-1712, 8 used
	03-08292K10	machine screw, 2-56x3/16, 2 used
	43-08773L01	button
	64-08769L01	front panel
	84-02213S01	printed circuit board

APPENDIX I
DECIMAL-BINARY-HEXADECIMAL CONVERSION TABLE

Dec	Binary	Hex	Dec	Binary	Hex	Dec	Binary	Hex
0	00000000	00	85	01010101	55	170	10101010	AA
1	00000001	01	86	01010110	56	171	10101011	AB
2	00000010	02	87	01010111	57	172	10101100	AC
3	00000011	03	88	01011000	58	173	10101101	AD
4	00000100	04	89	01011001	59	174	10101110	AE
5	00000101	05	90	01011010	5A	175	10101111	AF
6	00000110	06	91	01011011	5B	176	10110000	B0
7	00000111	07	92	01011100	5C	177	10110001	B1
8	00001000	08	93	01011101	5D	178	10110010	B2
9	00001001	09	94	01011110	5E	179	10110011	B3
10	00001010	0A	95	01011111	5F	180	10110100	B4
11	00001011	0B	96	01100000	60	181	10110101	B5
12	00001100	0C	97	01100001	61	182	10110110	B6
13	00001101	0D	98	01100010	62	183	10110111	B7
14	00001110	0E	99	01100011	63	184	10111000	B8
15	00001111	0F	100	01100100	64	185	10111001	B9
16	00010000	10	101	01100101	65	186	10111010	BA
17	00010001	11	102	01100110	66	187	10111011	BB
18	00010010	12	103	01100111	67	188	10111100	BC
19	00010011	13	104	01101000	68	189	10111101	BD
20	00010100	14	105	01101001	69	190	10111110	BE
21	00010101	15	106	01101010	6A	191	10111111	BF
22	00010110	16	107	01101011	6B	192	11000000	C0
23	00010111	17	108	01101100	6C	193	11000001	C1
24	00011000	18	109	01101101	6D	194	11000010	C2
25	00011001	19	110	01101110	6E	195	11000011	C3
26	00011010	1A	111	01101111	6F	196	11000100	C4
27	00011011	1B	112	01110000	70	197	11000101	C5
28	00011100	1C	113	01110001	71	198	11000110	C6
29	00011101	1D	114	01110010	72	199	11000111	C7
30	00011110	1E	115	01110011	73	200	11001000	C8
31	00011111	1F	116	01110100	74	201	11001001	C9
32	00100000	20	117	01110101	75	202	11001010	CA
33	00100001	21	118	01110110	76	203	11001011	CB
34	00100010	22	119	01110111	77	204	11001100	CC
35	00100011	23	120	01111000	78	205	11001101	CD
36	00100100	24	121	01111001	79	206	11001110	CE
37	00100101	25	122	01111010	7A	207	11001111	CF
38	00100110	26	123	01111011	7B	208	11010000	D0
39	00100111	27	124	01111100	7C	209	11010001	D1
40	00101000	28	125	01111101	7D	210	11010010	D2
41	00101001	29	126	01111110	7E	211	11010011	D3
42	00101010	2A	127	01111111	7F	212	11010100	D4
43	00101011	2B	128	10000000	80	213	11010101	D5
44	00101100	2C	129	10000001	81	214	11010110	D6
45	00101101	2D	130	10000010	82	215	11010111	D7
46	00101110	2E	131	10000011	83	216	11011000	D8
47	00101111	2F	132	10000100	84	217	11011001	D9
48	00110000	30	133	10000101	85	218	11011010	DA
49	00110001	31	134	10000110	86	219	11011011	DB
50	00110010	32	135	10000111	87	220	11011100	DC
51	00110011	33	136	10001000	88	221	11011101	DD
52	00110100	34	137	10001001	89	222	11011110	DE
53	00110101	35	138	10001010	8A	223	11011111	DF
54	00110110	36	139	10001011	8B	224	11100000	E0
55	00110111	37	140	10001100	8C	225	11100001	E1
56	00111000	38	141	10001101	8D	226	11100010	E2
57	00111001	39	142	10001110	8E	227	11100011	E3
58	00111010	3A	143	10001111	8F	228	11100100	E4
59	00111011	3B	144	10010000	90	229	11100101	E5
60	00111100	3C	145	10010001	91	230	11100110	E6
61	00111101	3D	146	10010010	92	231	11100111	E7
62	00111110	3E	147	10010011	93	232	11101000	E8
63	00111111	3F	148	10010100	94	233	11101001	E9
64	01000000	40	149	10010101	95	234	11101010	EA
65	01000001	41	150	10010110	96	235	11101011	EB
66	01000010	42	151	10010111	97	236	11101100	EC
67	01000011	43	152	10011000	98	237	11101101	ED
68	01000100	44	153	10011001	99	238	11101110	EE
69	01000101	45	154	10011010	9A	239	11101111	EF
70	01000110	46	155	10011011	9B	240	11110000	F0
71	01000111	47	156	10011100	9C	241	11110001	F1
72	01001000	48	157	10011101	9D	242	11110010	F2
73	01001001	49	158	10011110	9E	243	11110011	F3
74	01001010	4A	159	10011111	9F	244	11110100	F4
75	01001011	4B	160	10100000	A0	245	11110101	F5
76	01001100	4C	161	10100001	A1	246	11110110	F6
77	01001101	4D	162	10100010	A2	247	11110111	F7
78	01001110	4E	163	10100011	A3	248	11111000	F8
79	01001111	4F	164	10100100	A4	249	11111001	F9
80	01010000	50	165	10100101	A5	250	11111010	FA
81	01010001	51	166	10100110	A6	251	11111011	FB
82	01010010	52	167	10100111	A7	252	11111100	FC
83	01010011	53	168	10101000	A8	253	11111101	FD
84	01010100	54	169	10101001	A9	254	11111110	FE
						255	11111111	FF

APPENDIX II

REGULATED POWER SUPPLIES
LVS-45E-12-41335
LVS-45E-15-41335

DC OUTPUT - Voltage regulated for line and load. For voltage and current ratings see Table I below.

TABLE I

LAMBDA MODEL	VOLTAGE RANGE		MAXIMUM CURRENT (AMPS) AT AMBIENT TEMPERATURE			MOTOROLA MODEL
	MIN	MAX	40°C	50°C	60°C	
LVS-45E - 12-41335	13.4	14.4	3.7	3.2	2.6	FPN5502A
LVS-45E - 15-41335	15.5	16.6	3	2.5	2	FLN4606A

NOTE:
1. DC output will be min. value @60°C to max. value @ -30°C with linear interpolation between the above points (See Table 1).
2. LVS-45E-12-41335 will meet all specifications when loaded to 7A for not longer than 60 SEC, operation @7A is limited to max 10% duty cycle.
3. LVS-45E-15-41335 will meet all specifications when loaded to 6A for not longer than 30 SEC, operation @6A is limited to max 20% duty cycle.

Current range must be chosen to suit the appropriate ambient temperature. Current ratings apply for entire voltage range.

REGULATED VOLTAGE OUTPUT

Regulation (line) ....0.4% for input variations from 187-250V AC or 250-187V AC, 105-132V AC or 132-105V AC
Regulation (load) ....0.8% for load variations from no-load to full-load or full-load to no-load.
Ripple and Noise ....300mV peak-to-peak.
Temperature Coefficient.........0.02%/°C.

OVERSHOOT - No overshoot under conditions for power turn-on, turn-off or power failure.

AC INPUT - 187-265 volts AC or 105-132 at 47-60Hz. Input power 80 watts maximum*.
* With output loaded to full current rating and input voltage 250 volts AC at 50 Hz.
For 110VAC line, short PcB turret terminal A and B together. For 220VAC line, leave A and B open.

DC INPUT - 260-370 volts DC and power supply must wired for 220VAC input (See Fig. 1-Turrets not shorted).

EFFICIENCY - 62% minimum.

OVERLOAD PROTECTION - Automatic electronic current limiting circuit with automatic recovery limits short circuit output current to a safe preset value, protecting load and power supply when direct shorts occur. Sustained short circuit operation for more than 30 seconds may cause damage to power supply.

HOLD-UP TIME - Output will remain within regulation limits for at least 20 msec after loss of AC power at full-load with nominal output voltage and 187 V AC input at 50 Hz., or 105V AC at 60Hz.

INPUT AND OUTPUT CONNECTIONS - Molex connector, type 5289-4A, contains all terminals for AC input connections; Molex connector, type 5287-5A, contains all terminals for DC output ground and power failure connections. AC input terminals are marked L and N for hot side and neutral respectively.

COOLING - Convection cooled; no external blowers required.

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE - Continuous duty from 30° to 60°C with corresponding load current derating for operation above 40°C. When starting at -30°C, a warm up period of 4 mins is required.

STORAGE TEMPERATURE - 30°C to +85°C.

DC OUTPUT CONTROL - Screwdriver voltage adjust control permits adjustment of DC output voltage. DC output LED provides indications of DC output voltage availability.

WARRANTY - 90 day warranty from date of shipment .... materials and labor.

PHYSICAL DATA
Size ....37 x 97 x 159 mm.
Weight ....405 gr. net.
Finish ....Chassis aluminium, non plated.

MOUNTING - Two surfaces with threaded mounting holes can be utilized for mounting this unit. Air circulation is required when unit is mounted in confined area.

POWER FAILURE - When supplying AC input, a signal of 12V min will exist on I+Pin on output connector. Upon AC failure the signal will drop to zero with 5 kohm impedance.

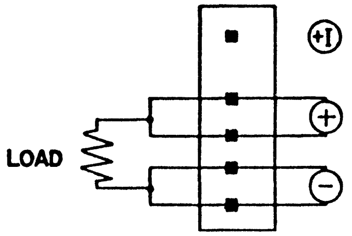


Fig. 1 – DC Output Connection Diagram.

For 105-132V AC short turrets A&B on P.C. Board

187-250 VAC
or
105-132 VAC
47-63 Hz
or
260-370 V DC

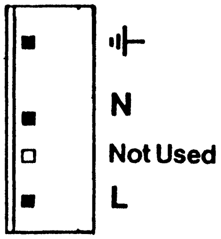
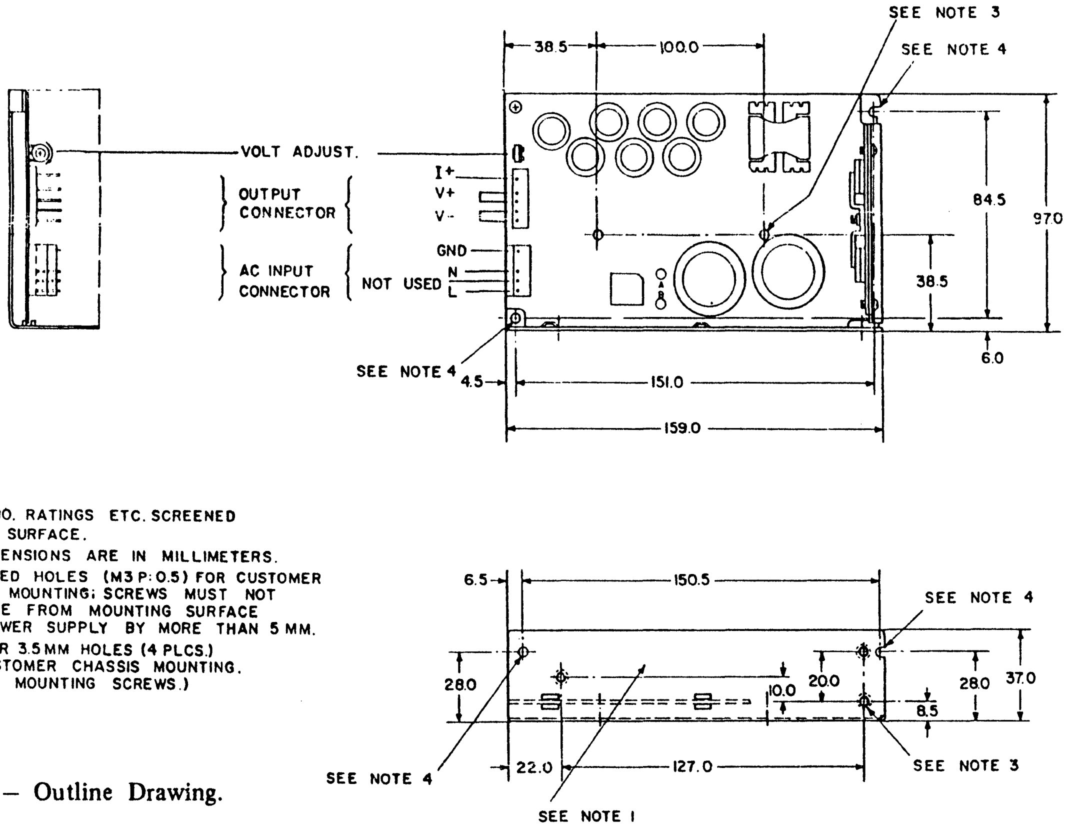


Fig. 2 – AC Connection Diagram.



NOTES:
1. MODEL NO. RATINGS ETC. SCREENED ON THIS SURFACE.
2. ALL DIMENSIONS ARE IN MILLIMETERS.
3. 5 TAPPED HOLES (M3 P:0.5) FOR CUSTOMER CHASSIS MOUNTING; SCREWS MUST NOT PROTRUDE FROM MOUNTING SURFACE INTO POWER SUPPLY BY MORE THAN 5 MM.
4. DIAMETER 3.5MM HOLES (4 PLCS.) FOR CUSTOMER CHASSIS MOUNTING. (USE M3 MOUNTING SCREWS.)

Fig. 3 – Outline Drawing.

LVS-45E-12-41335) THEORY OF OPERATION
LVS-45E-15-41335)

GENERAL

The LVS 45E - 12 consists of the following elements:

Input Circuit
Pulse Width Modulated Flyback Inverter
Output Rectifier and Filter
Control Integrated Circuit

FUNCTIONAL DESCRIPTION

Input circuit

Single phase AC input power is applied to bridge CR1 through EMI suppression choke LI, Resistor R1 limits the inrush current and acts as a fuse in excessive currents due to internal failure varistor R30 protects against high line spikes.

The input rectifier and capacitors C6, C26 form a voltage doubler when points A-B are shorted or a full wave rectifier when points A-B are open.

The input capacitors C6, C26 provide power to the bipolar switch Q1 and via R26, C7 power to the control circuit IC3.

PULSE WIDTH MODULATED FLYBACK

The inverter is a single ended configuration flyback using one power bipolar switch. During "ON" time a positive pulse is delivered to the base from the control circuit (pin 6) via resistors R9, R10 and capacitors C12, C13. During "OFF" time, pin 6 shorts to ground and negative base current flys through CR3. Negative base voltage is kept by C13. Switching action of Q1 delivers positive and negative pulses to T1 primary.

OUTPUT RECTIFIER AND FILTER

The transistor "ON" time produces a negative secondary pulse which causes CR6 to cut off. Energy is stored in the primary winding of T1. "OFF" time produces a positive secondary pulse, CR6 conducts and the primary stored energy is transferred to the load through the secondary winding. Output ripple attenuation is accomplished via output capacitors C17 _ C23 and L2.

CONTROL INTEGRATED CIRCUIT IC3

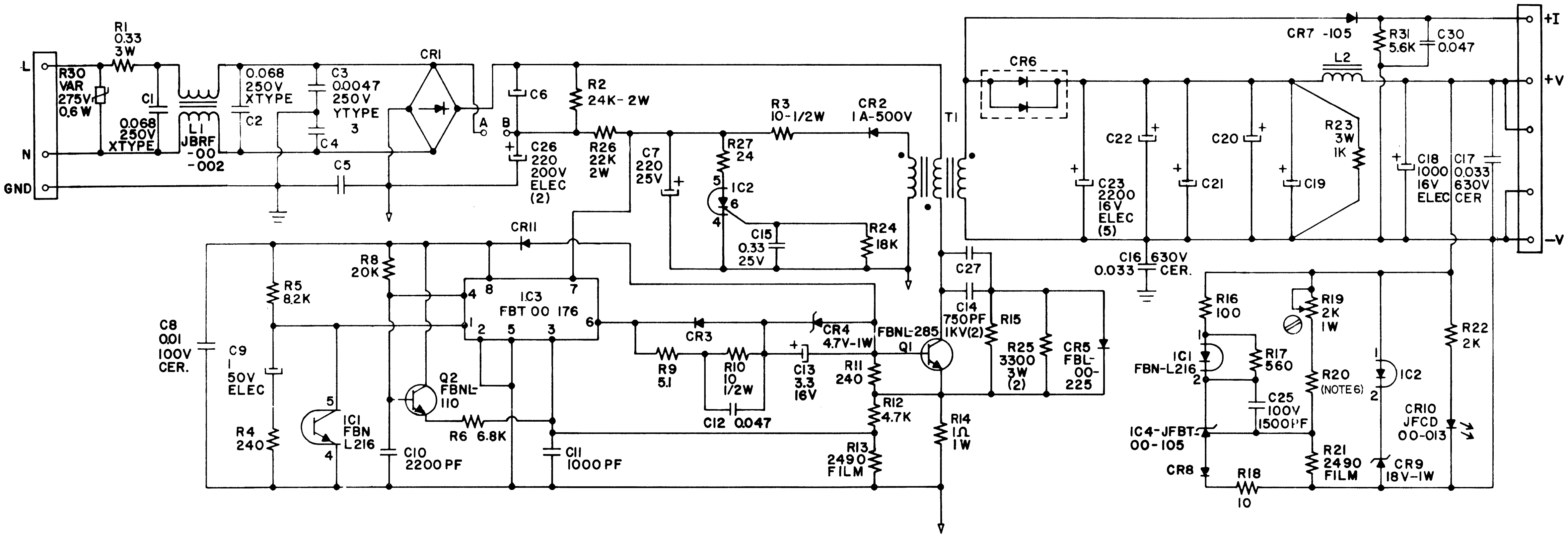
Oscillator Section : IC3 Pin 4 works in conjunction with R8 and C10 to set the oscillator frequency 40kHz. R8 and C10 sets the maximum on time, C10 and an internal resistor sets the OFF time.

PULSE WIDTH MODULATOR SECTION: Pulse width modulation necessary to control the output voltage is determined by comparing error signal to a ramp signal created by the primary current flowing through R14 and the voltage divider R12, R13. Changes in the output are sensed and divided by R19, R20, R21. This signal is fed to the reference of IC4 which controls the current through the opto-coupler diode IC1. Collector voltage of IC1 opto-transistor is fed into IC3 pin 1 and compared to the ramp on IC1 pin 3 to set the pulse width requried to maintain the desired output voltage.

CURRENT LIMIT AND SHORT PROTECTION: Pulse by pulse current limit is done by the ramp voltage fed to IC3 pin 3. When this voltage reaches IV the on time is terminated. The ramp is created by the primary current and this current will be limited to the valve which corresponds to IV on pin 3. The voltage needed for IC3 operation is fed on pin 7. IC3 starts with 16V on pin 7 and stops with 10V on pin 7. Start up os achieved via R26 and then the extra widning on T1 sets the voltage on pin 7. This voltage is a replica of the output voltage. When current limit occurs and output voltage drops - pin 7 drops below a certain output voltage pin 7 drops below 10V and the curcuit goes into hick up mode.

POWER SUPPLY

MODELS FPN5502A, FLN4606A



NOTES:

1. RESISTORS ARE 1/4 W CARBON FILM WITH VALUES IN OHMS UNLESS OTHERWISE NOTED.
2. CAPACITOR VALUES ARE IN MICROFARADS UNLESS NOTED.
3. RESISTOR TOLERANCES: CARBON FILM ±5%, WIREWOUND ±5%, FILM ±1%.
4. CAPACITOR TOLERANCES ±20% UNLESS OTHERWISE NOTED. FOR CAP. VALUES SEE BOM.
5. ⊘ INDICATES ADJUSTMENT OR CALIBRATION CONTROL.
6. FOR 15V POWER SUPPLY, R20 IS 8.8K. FOR 12V POWER SUPPLY, R20 IS 8K.

SCHEMATIC DIAGRAM
REGULATED POWER SUPPLY
LVS-45E-12-41335
LVS-45E-15-41335
LAMBDA ELECTRONICS
DIVISION OF Veeco INSTRUMENTS INC.

73C02952G42-0

parts lists

FPN5502A Power Supply and Hardware PL-0602-O

Reference Symbol	Motorola Part No.	Description
	01-02246H14	Power supply main board
	03-02443C69	Screw, 8-32 x 3/4"; 2 used
	03-10903A07	Screw, machine 3 x 0.5 x 6; 3 used
	04-00007671	Washer, lock; 2 used
	04-02440C16	Washer, flat .170 x 3/8" x .032; 2 used
	04-05465C01	Washer, .112 x .245 x .012; 3 used
	04-10058A74	Washer, flat; 2 used
	07-02419L01	Bracket
	54-02588L01	Power supply label
	01-02246H14	**Power Supply (Lambda) LVS45E-12-41335**

Reference Symbol	Lambda Part No.	Description
		Capacitors, fixed mF unless stated otherwise
C1,C2	HCDL-68-002	68000 pF, 250 V
C3-C5	CDK-47-027	4700 pF, ±20%; 250 V
C6,C26	HCBR-22-001	220, 200 V
C7	ICBR-221E35	220, 25 V
C8	ICGL-102A10	.01, 100 V
C9	JCBN-101H35	1, ±20%; 50 V
C10	CJK-22-002	2200 pF, ±5%; 100 V
C11	CDK-10-010	.001, 200 V
C12,C30	HCGL-47-001	.047, 100 V
C13	CBN-33-077	3.3, ±20%; 16 V
C14,C27	CDJ-75-023	750 pF, 1000 V
C15	JCDM-33001	.33, 25 V
C16,C17	JCGL-332-J12	.033, 630 V
C18	JCBS-101C35	1000, 16 V
C19-C23	JCBS-221C35	2200, ±20%; 16 V
C25	HCDK-15-001	1500 pF, 100 v
		Connectors
CON1	JHAR-00114	5289-5A
CON2	JHAR-00112	5287-5A
		Diodes
CR1	HFBL-00-001	3A, 400 V
CR2,CR3,CR7	FBL-00-105	1A, 500 V
CR4	FBMZ-217	4.7 V,1W, ±5%; Zener
CR5	FBL-00-225	3A, 1000 V
CR6	JFBL-00-201	1A, 200 V
CR8,CR11	FBL-00-082	.4A, 70 V
CR9	FBMZ-154	18 V, 1W, ±5%
CR10	JFCD-000013	LED
		Coils
L1	JBRF00002	EMI Choke
L2	JBRB11002	Output Coil
		Transistors
Q1	FBN-L285	transistor
Q2	FBN-L110	30 V, NPN
		Resistors: fixed ±5% 1/4W, ohms unless stated otherwise
R1	DFM-39-043	.33 ±5%; 3W
R2	DHB-2435	24k, 2W, ±5%
R3,R10	DDE-1005	10, 1/2W, ±5%
R4,R11	DDB-2415	240
R5	DDB-8225	8.2k
R6	DDB-6825	6800
R8	DDB-2035	20k
R9	DDB-51G5	5.1
R12	DDB-4725	4700
R13,R21	DCS-25-130	2490, 1/4W, 1%
R14	DGB-10G5	1, ±5%; 1W
R15,R25	DFS-33-072	3300, 3W, 3%
R16	DDB-1015	100
R17	DDB-5615	560
R18	DDB-1005	10
R19	IDRS-2001332	2k, 1W, ±20%;Variable
R20	DCS-81-167	8k, ±1%, 1/4W
R22	DDB-2025	2k
R23	DFP-91-082	91, 3W, 5%
R24	DDB-1835	18k
R26	DHB-2235	22k, 2W, ±5%
R27	DDB-2405	24
R30	DVR-27-002	275 V, 0.6W Varistor
R31	DDB-5625	5.6k
		Transformers
T1	ABA-LYS-45ESP	
		Integrated Circuits
IC1	FBN-L216	Opto Coupler
IC2	JFBT-00109	Opto SCR.
IC3	FBT-00-176	
IC4	JFBT-00-105	
		Non Referenced Items
	HTCE-050-005	Gap 7mm
	HTCE-050-004	Ferrite Core
	HVVM-06-002	Bobbin
	JB3-03-066	3x6 screw, PH. PAN. HO
	JB3-26-086	3x8 screw, PH. PAN. HO
	JK3-05-016	3 split LK Washer
	JB3-03-086	3x8 screw, PH. PAN. HO
	L-LVS-45V-200	Transistor & Diode Bracket
	L-LVS-45V-100	Chassis
	L-LVS-45V-321	Spring
	HHKA-04-001	Connector
	HHKA-05-001	Connector
	LVS45E12-41335	Instruction Manual
	JWSE-00077	Insulator
	HAL-02-378	Printed Circuit Board

Note: When ordering this power supply from Motorola, specify kit number FPN5502A.

FLN4606A 15 V Power Supply PL-0622-O

Reference Symbol	Motorola Part No.	Description
	01-02246H16	**Power Supply (Lambda) LVS45E-15-41335**

For parts list details refer to subassembly 01-02246H14 in Model FPN5502A, except for:

R20		8.87k

Note: When ordering this power supply from Motorola, specify kit number FLN4606A.

MOTOROLA

POWER SUPPLY/CHARGER
15V/10A
MODELS FPN5522A/AA

Instruction Manual

68P02973G60-A

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(STANDARD)

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POWER SUPPLY/CHARGER
15V/10A
MODELS FPN5522A/AA

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68P02973G60-A

MOTOROLA INC.
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POWER SUPPLY/CHARGER
15V/10A
MODELS FPN5522A/AA

1. GENERAL DESCRIPTION

The FPN5522A is a dual-function instrument that can be used as a power supply (12.9-15.1V ; 0-10A) or as a charger for 12V batteries. FPN5522A Power Supply output characteristics are shown in Figure 1.

The FPN5522A is a fully regulated power source consisting of a switching configuration and control circuits for alarm and protection. The front panel features are shown in Figure 3.

The power supply can deliver 12.9-15.1V at a total current of 8A.

In the case of a power failure (or the 6A fuse has blown) an externally connected 12V battery will automatically deliver power to the load.

If the battery voltage drops below 10.4V, it is automatically disconnected from the system to save it from deep discharge and eventual destruction.

NOTE

Always disconnect the battery when the power switch is in the OFF position. If the battery is connected with reversed polarity, the 10 A fuse will blow.

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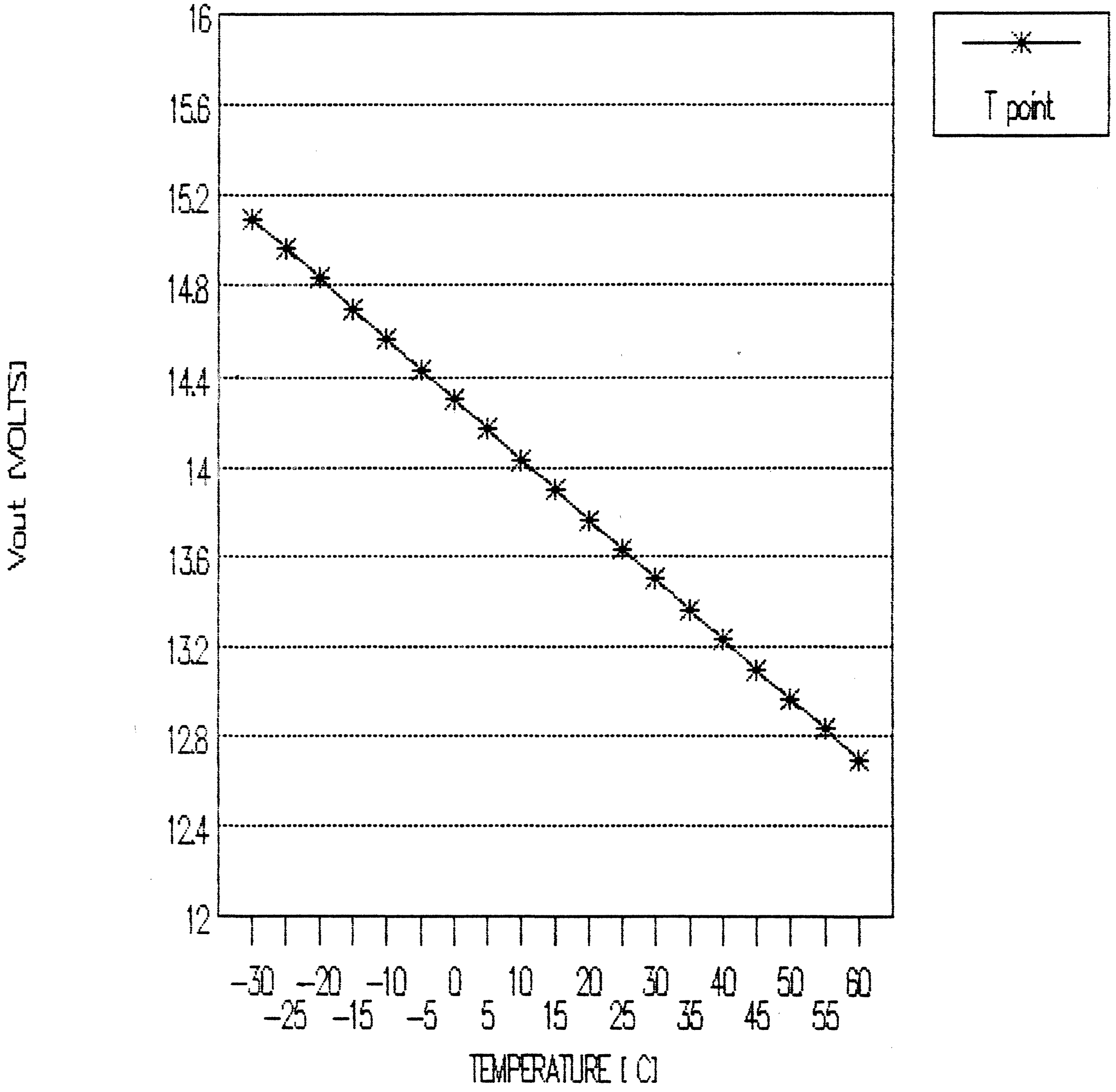

FIGURE 1. OUTPUT VOLTAGE VS. TEMPERATURE

2. SPECIFICATIONS

2.1 ELECTRICAL

DC output voltage, regulated for line and load *

OUTPUT VOLTAGE RANGE	13.8V ± 5% @25°C, adjustable
TEMPERATURE COMPENSATION (OUTPUT VOLTAGE)	-26.7 mV/°C
MAXIMUM VARIATION FROM NOMINAL OUTPUT VOLTAGE (INCLUDING LINE REGULATION, LOAD REGULATION , AND LONG TIME STABILITY)	±1% of nominal output
AC INPUT VOLTAGE	187-265 Vac or 105-132 Vac 47-60 Hz
OUTPUT CURRENT RATING	Repetitive Cycle,refer to Fig.2
OUTPUT CURRENT(CONTINUOUS)	0.1-8 A @ 60°C **
EFFICIENCY	62% minimum
OVERLOAD PROTECTION	Automatic, electronic current limiting circuit , with automatic recovery. Limits short circuit output current to a safe preset value, protecting load and power supply when direct shorts occur.
OVERPOWER PROTECTION	Automatic electronic power protection against overheating when the power exceeds ratings.
OVERVOLTAGE PROTECTION	Constant voltage: up to 17V max.

* In no load state the voltage should preferably be as stable as possible - refer to note below **.

** Bleeder is connected in no-load state (i.e., sensing of current consumption).

HOLD-UP TIME	Outputs will remain within regulation limits for at least 20 ms after loss of AC power at full load with nominal output voltage and 187 Vac at 60 Hz.
COOLING	Convection cooled , no external blowers required.
DIMENSIONS	247x131x51mm (9.7'x5.1'x2').
POWER FAILURE OUTPUT	When applying AC input, a signal of 12V minimum (17V maximum) will exist on that output. Upon AC failure, the signal will drop to zero with a 5 kΩ pull-down resistor.
SURGE PROTECTION	Per IEEE Standard no.587.
STANDBY CURRENT	Less than 1.1 mA from battery when AC current is off.
DC OPERATION	Fully operational with DC, 240 V to 370 V.
OVERSHOOT (INPUT VOLTAGE VARIATIONS)	No overshoot under conditions for power turn-on , turn-off or power failure.
OVERSHOOT (LOAD VARIATIONS)	Momentary change in output voltage during transition from 10A load to 0.1 A load: $\Delta V \leq 0.3$ V ; $T \leq 7$ msec.
UNDERSHOOT	Momentary change in output voltage during transition from 0.1A load to 10 A load : $\Delta V \leq 0.5$ V ; $T \leq 5$ msec.
SAFETY STANDARDS	UL , CSA , TUV , VDE.
RADIATION EMISSION TEST	Per FCC Part 15, Class A

2.2 ENVIRONMENTAL

OPERATING TEMPERATURE RANGE	-30°C to +60°C , tested per EIA standards RS-152-B , RS-204-C.
RELATIVE HUMIDITY	90% without condensation @ 50°C tested per EIA standards RS-152-B , RS-204-C.
STORAGE TEMPERATURE RANGE	-40°C to +85°C , tested for 168 hours at range limits.
ELECTROSTATIC DISCHARGE (ESD)	Per Motorola standard 12N80973A32.
DROP	Per Motorola standard 12M05019A86.
PACKAGING	Per Motorola standard 12M80973A04.

2.3 RELIABILITY

FAILURE RATE	$20*10^{-6}$ or MTBF=50,000 hours , @25°C.
STRESS	Electrical or thermal load will be up to 80% of maximum specified by component manufacturers.

2.4 ADDITIONAL DETAILS

The battery will be disconnected from the power supply output at a voltage level of Vout=10.4±0.2V DC.

The battery will be reconnected to the power supply output at a voltage level of Vout=12.2±0.2V DC.

A warning that the battery is about to be disconnected is sent at a time T1=80±15s prior to disconnection.

The BAT LOW time duration is set for T2=0.5s.

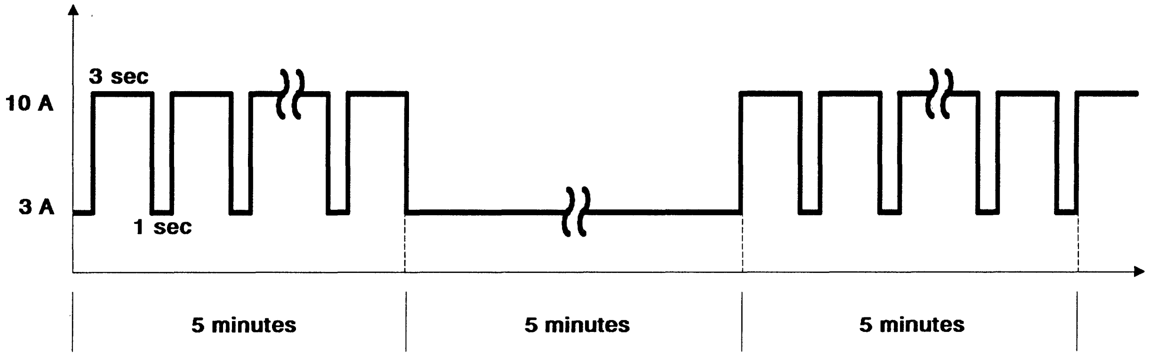

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FIGURE 2. REPETITIVE CYCLE

3. INSTALLATION

3.1 GENERAL

The package design of the power supply provides adequate cooling at high ambient temperatures without cooling fans.

The output terminals are isolated from the AC power line and from the chassis. The -Vout terminal may be grounded as desired.

3.2 INSTALLATION INSTRUCTIONS

For proper use of the FPN5522AA/FPN5522A Power Supply, the following steps must be performed:

1) Ensure a free air path above and behind the unit.
2) Connect the unit to 230 V ac (115 V), 47-63 Hz single phase, 6 A source.
3) Set DC Switch S2 to the ON position; adjust the voltage to the desired amount, using the Voltage Adjustment Control R65.
4) Connect load and/or battery to the appropriate terminal connectors (observe correct polarity).
5) Set DC Switch S2 to the ON position, and make sure that:
    a) ON lamp is lit,
    b) AC FAIL alarm (P.F.) is OFF.

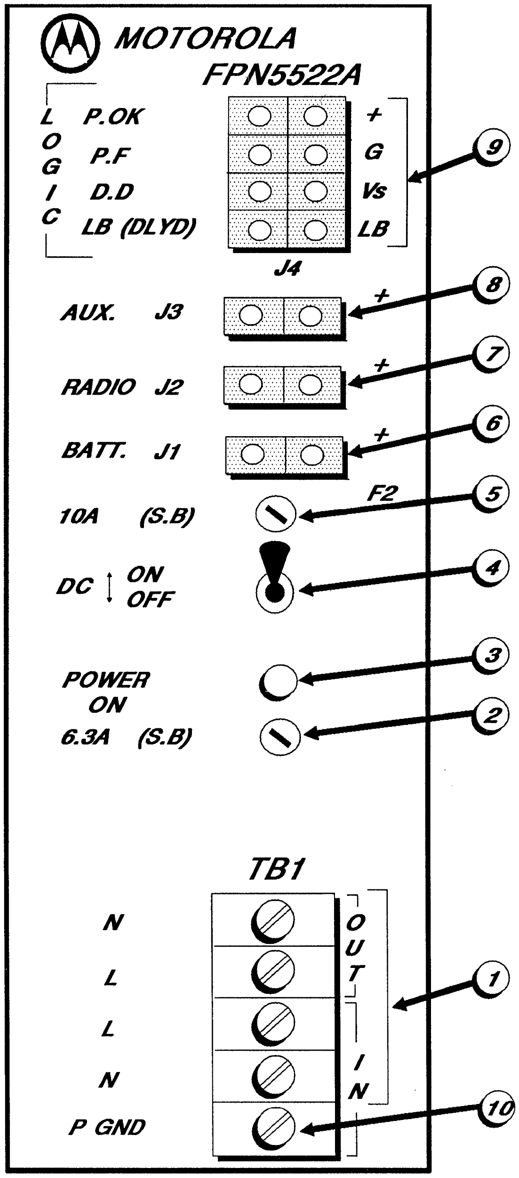
The alarm bit will turn on in the following circumstances:

a) Output voltage drops below 10.4 ± 0.2 V,
b) Output current exceeds 11 A.

In case of a drop in line voltage, the battery will provide current to the load until the battery voltage reaches its threshold value of 10.4 ± 0.2 V.

In cases where there is a need to supply power to the load without the presence of input line voltage, perform the following steps:

a) Connect a usable charged battery,
b) Turn on Switch S2.



NOTE:
FPN5522A operates at 110 Vac.
FPN5522AA operates at 220 Vac.

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FIGURE 3. FRONT PANEL

Table 1. Controls and Connections

No. in Figure	Name	Symbol	Function
1	Connector	TB1	Line connections
2	Fuse	F1	Located on primary circuit; protects against current overload (6 A)
3	On Lamp	DS1	Indicates that the power supply is working
4	DC Switch	S2	ON/OFF DC output
5	Fuse	F2	Protects against current overload to battery (10 A)
6	Connector	J1	Connects terminals to 12 V battery
7	Connector	J2	Connects terminals to radio
8	Connector	J3	Connects terminals to auxiliary circuits
9	Connector	J4	Connects +, G, Vs, LB, P.OK, P.F. and LB (DLYD) signals
10	Ground Binding Post		Ground terminal

4. FUNCTIONAL DESCRIPTION

The FPN5522A is a Switching Mode Power Supply comprising four main sections (see schematic diagram):

1) Input Filters
2) DC/DC Converter
3) Output Filter
4) Charger Circuit

4.1 INPUT FILTERS

There are two input filters:
a) E.M.I. and R.F.I. Filter
b) D.C. Input Filter

The E.M.I. and R.F.I. Input Filter consists of three capacitors and two inductors before the rectifier bridge.

The D.C. Input Filter consists of four electrolytic capacitors and two inductors. All the capacitors of this filter are low E.S.R. Capacitors.

4.2. DC/DC CONVERTER

The DC/DC Converter is of the forward type. It is based on a fixed frequency Current Mode PWM Controller. The converter includes Pulse-by-Pulse Current Limiting and OverVoltage features.

The PWM Controller used is the UC1842 manufactured by Unitrode.

Switching frequency is fixed by resistor R19 and capacitor C19, and set at 100 KHz.

The controller includes several internally implemented circuits: 1) undervoltage lockout, featuring a start up current of less than 1mA, 2) a precision reference, trimmed for accuracy at the error amplifier input, 3) logic to insure latched operation, 4) a PWM comparator, which also provides current limit control, and 5) a totem pole output stage designed to source or sink high peak current.

There are also two protection circuits in the DC/DC convertor. The first is implemented by Q5 and Q6 transistors and U6. This circuit receives feedback from the DC Input and limits the Duty Cycle of the PMW controller at 12% over the Duty Cycle fixed by the DC input voltage. This feature protects the switching MOSFET in the case of output feedback loop failure, by insuring demagnetization of transformer T1.

The second is implemented by U7 , and insures start-up at 170V input, and turns OFF at 165V input.

4.3. OUTPUT FILTER

The Output Filter consists of three inductors and two low E.S.R. capacitors.

4.4. CHARGER CIRCUIT

Battery connection and disconnection are implemented by U9 and U10, connection at 12.2V and disconnection at 10.4V.

The hysteresis effect is implemented by R52 and U10D.

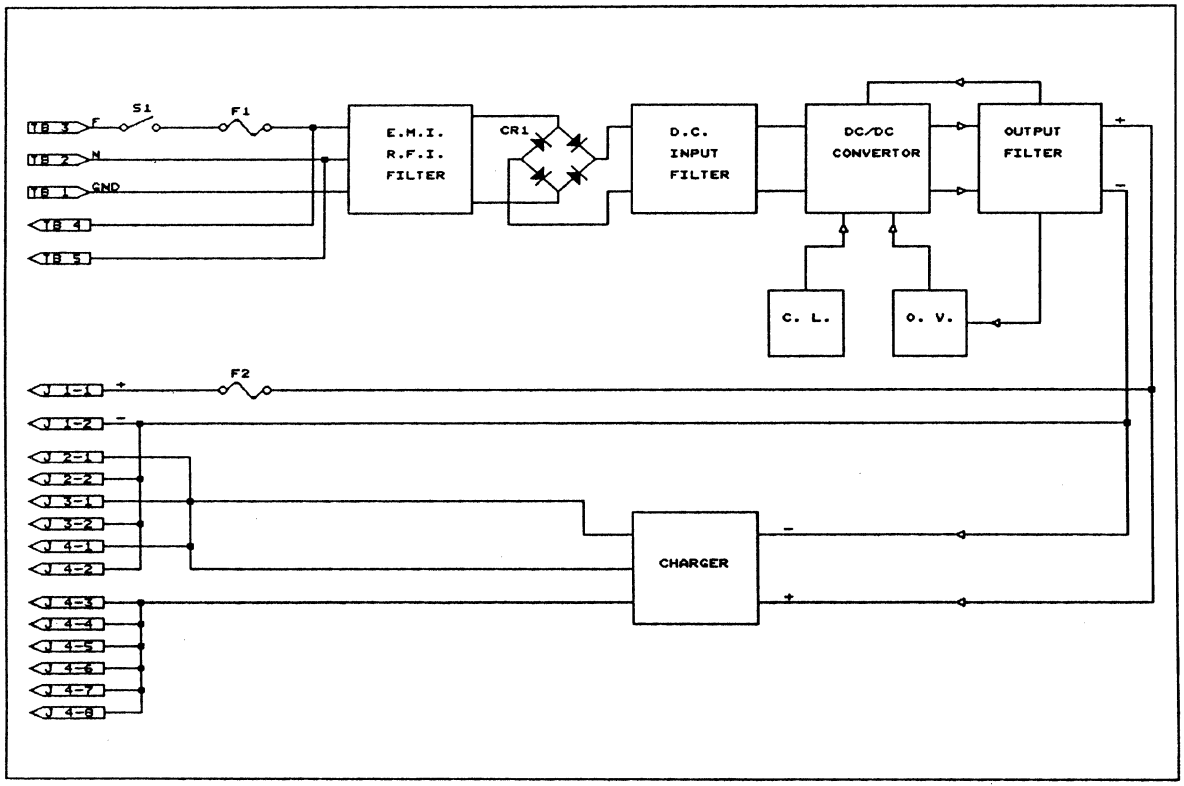
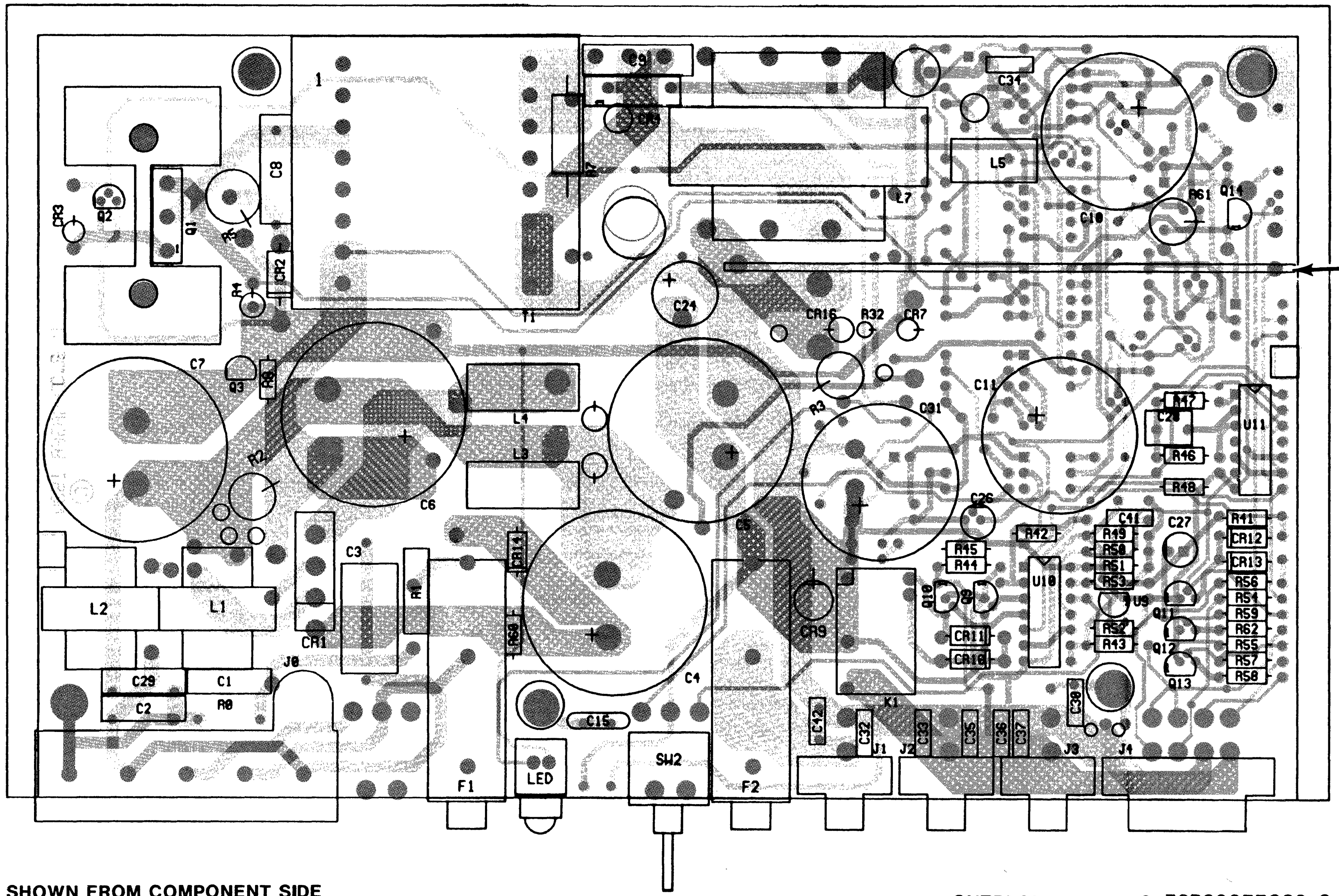


FIGURE 4. BLOCK DIAGRAM

POWER SUPPLY/CHARGER

MODELS FPN5522A/AA

MAIN BOARD

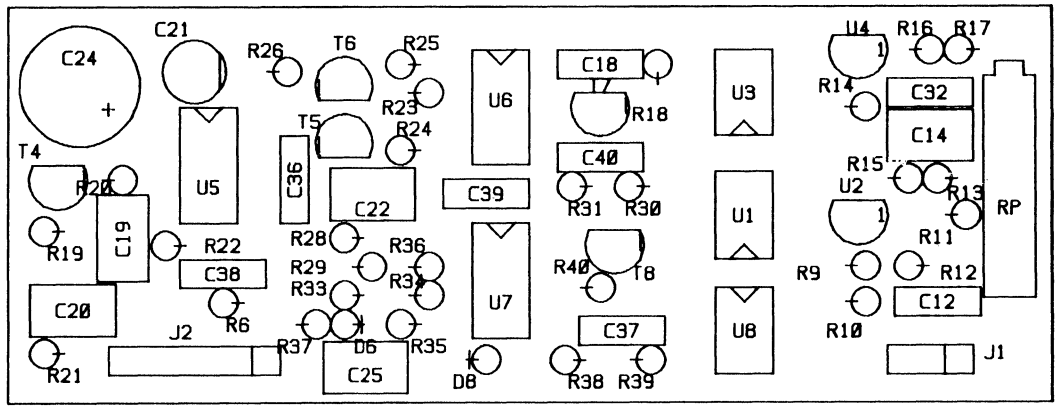


CONTROLLER BOARD LOCATION

SHOWN FROM COMPONENT SIDE

OVERLAY ● 79B02977G83-0
COMPONENT SIDE ● 79B02980G84-0
SOLDER SIDE 79B02980G91-0

CONTROLLER

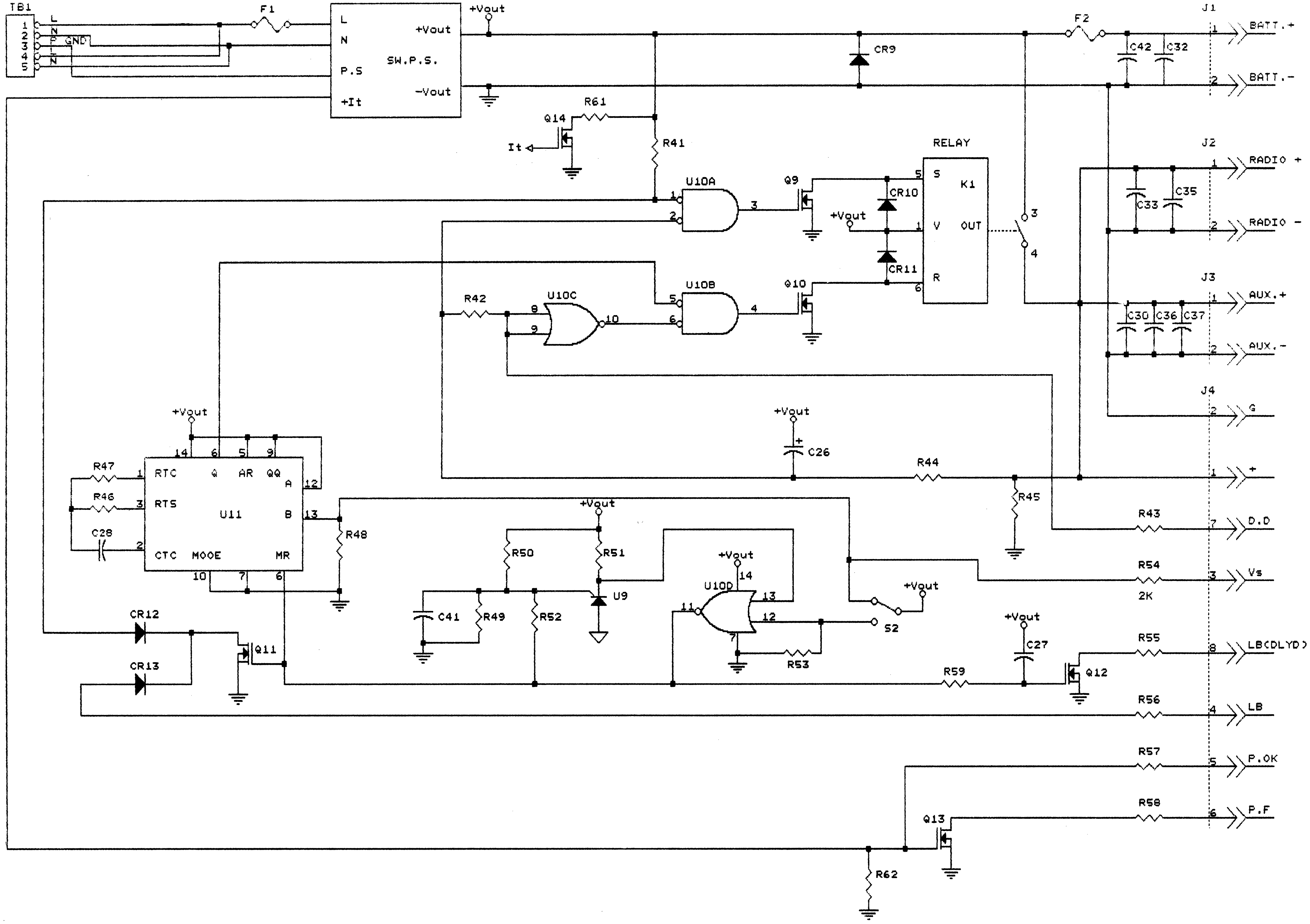


SHOWN FROM COMPONENT SIDE

OVERLAY ● 79A02977G84-0

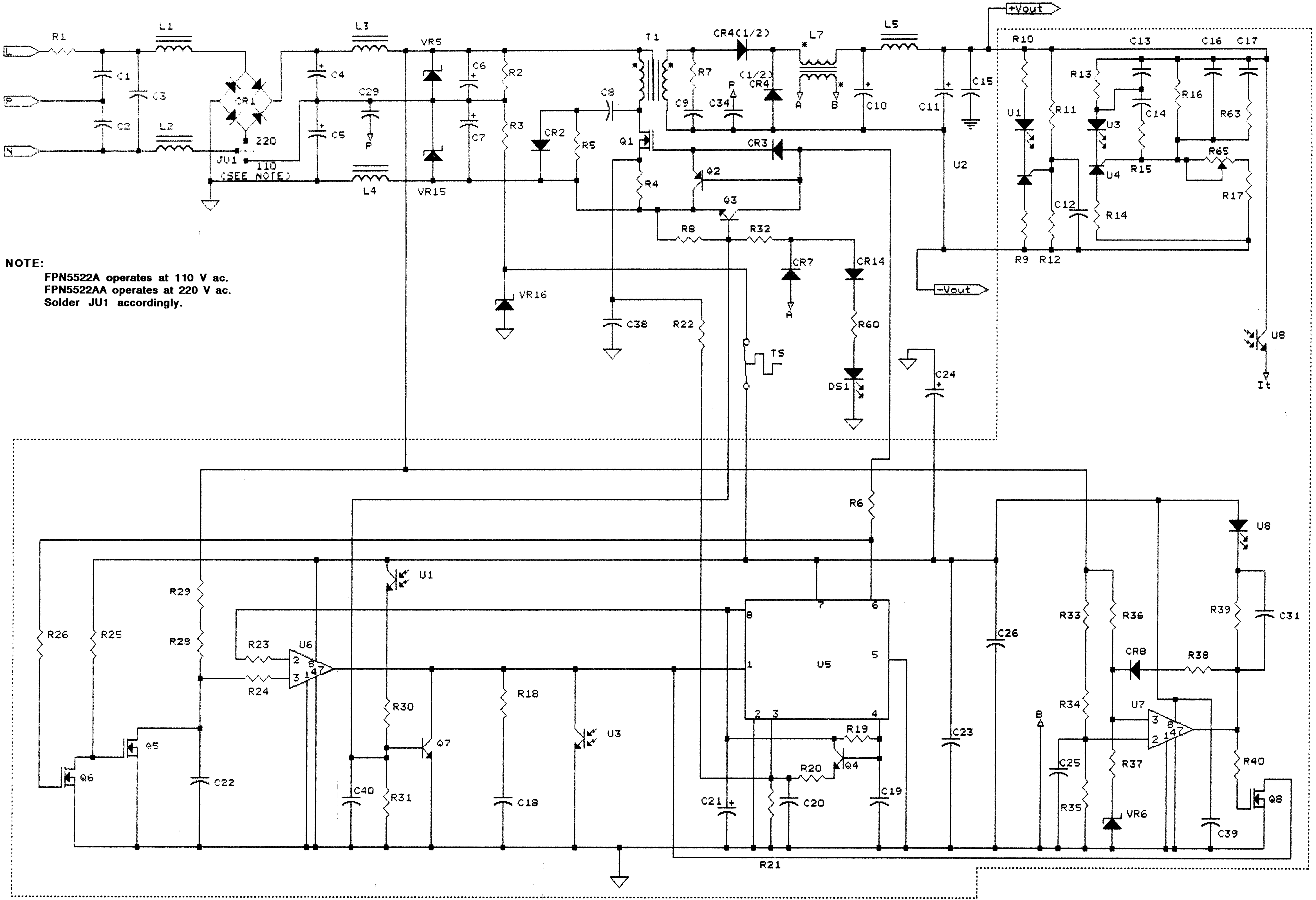
POWER SUPPLY/CHARGER

MODELS FPN5522A/AA



POWER SUPPLY/CHARGER

MODELS FPN5522A/AA



NOTE:
FPN5522A operates at 110 V ac.
FPN5522AA operates at 220 V ac.
Solder JU1 accordingly.

POWER SUPPLY/CHARGER

MODELS FPN5522A/AA

SYMBOL	MANUFACTURER	ORDERING CODE	DESCRIPTION
C1,2	WIMA	MP3Y-1nF-250VAC- 20%	1000pF-250Vac
C3	ERO	F1777-0,082uF-250VAC	0.082uF-250VAC
C4,5,6,7	SPRAGUE	80D-271-P200-KB2	270µF-200Vdc
C8	WIMA	FKP1-220pF-1600V-10%	220pF-1600Vdc-10%
C9	WIMA	FKP1-1000pF-1250V-10%	1000pF-1250V-10%
C10,11	SPRAGUE	80D-562-P025-HD5	5600µF-25V
C12	WIMA	MKC2-0.033µF-63V-10%	0.033µF-63V-10%
C13,17		N.U.	N.U.
C14	WIMA	FKP2-1000pF-100V-10%	1000pF-100V-10%
C15,23,26,30	MURATA	RPE113-X7R-224K-050	0,22uF-50V
C31,32,33,35	MURATA	RPE113-X7R-224K-050	0,22uF-50V
C36,37,39,42	MURATA	RPE113-X7R-224K-050	0,22uF-50V
C16	PHILIPS	CK-05-472	4700uF-100V
C18,41	MURATA	RPE132-X7R-683K-050	68nF-50V
C19	WIMA	FKP2-4700pF-63V-2.5%	4700pF-63V-2.5%
C20,38	PHILIPS	CK-05-102K	1000pF-100V
C21,26	SPRAGUE	499D-105-X9A1-025	1µF-25V
C22	WIMA	FKP2-220pF-100V-2.5%	220pF-100V-2.5%
C24	SPRAGUE	513D477M025-DG4	470µF-25V
C25,40	WIMA	FKP2-220pF-100V-10%	220pF-100V-10%
C27	SPRAGUE	499D-106-X9F1-016	10µF-16V
C28	WIMA	FKP2-0.01µF-63V-10%	0.01µF-63V-10%
C29	MURATA	DBE7150-F472-MVA1-KC	4700pF-250Vac
C34	PHILIPS	CK-06-103	0.01µF-100V
CR1	MOTOROLA	MDA970G6	Bridge 6A 600V
CR2	MOTOROLA	MUR4100	4A-1000V-75nS UF
CR3,12,13	MOTOROLA	1N5819	1A-40V SCH.
CR4	G.I.	FEP30CP	2X30A-100V UF
CR7,8,14	MOTOROLA	1N4148	0.1A-100V UF
CR9	MOTOROLA	MR752	6A-200V
CR10,11	MOTOROLA	1N4003	1A-200V
CR16	MOTOROLA	1N5355	18V-5W
CS2	SOUTH.	47-12-302-10	CAPTIVE SCREW
D.S.	ALUTRONIC	D1617/10	DISTANCE SLEEVE
DS1	SCHURTER	SRL.035.1240	LED
K1		DK1a-L2-12V	LATCHING RELAY
L1,2	MICROMETALS	E100-26	CORE
	COSMO	1226-2RYNITE	COIL
L3,4	MICROMETALS	T60-26	TOROID
L5	MICROMETALS	T51-8C/90	TOROID
L7	COSMO	3507-1-331-06	COIL
Q1	IXYS	IXTH5N100A	5A 2Ω 1000V
Q2	MOTOROLA	MPS2907A	0.6A-40V P.N.P.
Q3,4,7	MOTOROLA	MPS2222A	0.6A-40V N.P.N.
Q5,6,8,9,10	MOTOROLA	VN2222L	0.15A-60V 7.5Ω
Q11,12,13,14	MOTOROLA	VN2222L	0.15A-60V 7.5Ω
R1	SIEMENS	Q63023-S1100-M	N.T.C.10-2.4W
R2	DRALORIC	SXA-0933-10K-5%	10K-5%-5W
R3	DRALORIC	SXA-0933-9.1K-5%	9.1K-5%-5W
R4	DRALORIC	GF07-0.5-5%	0.5Ω-5%-0.5W
R5	DRALORIC	SXA-0922-1K-5%	1K-5%-3W
R6,32	DRALORIC	SXA-0204-18-5%	18Ω-5%-0.25W
R7	DRALORIC	SXA-0617-56-5%	56Ω-5%-2W
R8,30,31,39	DRALORIC	SMA-0204-3.3K-5%	3.3K-5%-0.25W
R9,14	DRALORIC	SMA-0204-10-5%	10Ω-5%-0.25W
R10	DRALORIC	SMA-0204-2.7K-5%	2.7K-5%-0.25W
R11,50	DRALORIC	SMA-0204-90.9K-1%	90.9K-1%-0.25W
R12	DRALORIC	SMA-0204-15.7K-1%	15.7K-1%-0.25W
R13,23,24	DRALORIC	SMA-0204-1K-5%	1K-5%-0.25W
R15	DRALORIC	SMA-0204-15K-1%	15K-1%-0.25W
R16	DRALORIC	SMA-0204-27.4K-5%	27.4K-5%-0.25W
R17	DRALORIC	KTY-86-205	2K-5%
R18,26	DRALORIC	SMA-0204-75-5%	75Ω-5%-0.25W
R19	DRALORIC	SMA-0204-3.32K-1%	3.32K-1%-0.25W
R20,22	DRALORIC	SMA-0204-232-1%	232-1%-0.25W
R21	DRALORIC	SMA-0204-1.32K-1%	1.32K-1%-0.25W
R25,54,60	DRALORIC	SMA-0204-2K-1%	2K-1%-0.25W
R28,29	DRALORIC	SMA-0204-412K-1%	412K-1%-0.25W
R33,34	DRALORIC	SMA-0204-499K-1%	499K-1%-0.25W
R35	DRALORIC	SMA-0204-28K-1%	28K-1%-0.25W
R36	DRALORIC	SMA-0204-1.2M-1%	1.2M-1%-0.25W
R37	DRALORIC	SMA-0204-2.49K-1%	2.49K-1%-0.25W
R38	DRALORIC	SMA-0204-10K-5%	10K-5%-0.25W
R40,57,62	DRALORIC	SMA-0204-4.7K-5%	4.7K-5%-0.25W
R41,44,45,53	DRALORIC	SMA-0204-100K-5%	100K-5%-0.25W
R42	DRALORIC	SMA-0204-1M-5%	1M-5%-0.25W
R43,63	DRALORIC	SMA-0204-10K-5%	10K-5%-0.25W
R46	DRALORIC	SMA-0204-243K-1%	243K-1%-0.25W
R47	DRALORIC	SMA-0204-121K-1%	121K-1%-0.25W
R48	DRALORIC	SMA-0204-470K-5%	470K-5%-0.25W
R49	DRALORIC	SMA-0204-24.3K-1%	24.3K-1%-0.25W
R51	DRALORIC	SMA-0204-5.6K-5%	5.6K-5%-0.25W
R52	DRALORIC	SMA-0204-511K-1%	511K-1%-0.25W
R55,56,58	DRALORIC	SMA-0204-1K-5%	1K-5%-0.25W
R59	DRALORIC	SMA-0204-56K-5%	56K-5%-0.25W
R61	DRALORIC	SXA-0922-110-5%	110Ω-5%-3W
R65	SFERN.	T18-5K-10%	5K-10%-0.4W
S2	APR	55236WAK+U272+VDE	SWITCH
SOG	P.S.M.	PB50-8-632-5/16LSS	STAND OFF
TS	THERMIK	S01.90.5.100	90°C 100mm
T1	PHILIPS	4322-21-33860	COIL
U1,8	MOTOROLA	4N35	OPTO COUPLER 7.5KV
U2,4,9	MOTOROLA	TL431ILP	COMPARATOR 2.5V
U3	MOTOROLA	H11AA1	OPTO COUPLER 7.5KV
U5	UNITRODE	UC1842J	P.W.M. 500KHz
U6,7	MOTOROLA	LM111J8	COMPARATOR U.F.
U10	MOTOROLA	MC14001BCP	QU 2IN. NOR
U11	MOTOROLA	MC140541BCP	OSCILATOR TIMER
VR5,15	MOTOROLA	1.5-KE-200C	TRANSIENT SUPPRES.
VR6	MOTOROLA	1N4691	6.2V-250mW
VR16	MOTOROLA	1N5355	18 V- 5W
--	--	--	--
F1,2	SCHURTER	FAU.031.3577	FUSE HOLDER
--	SCHURTER	034.5140	FUSE 6.3A
--	SCHURTER	034.5145	FUSE 10A
--	SCHURTER	FEK.031.1661	COVER
H.S.	EG&G	647-10-ABP	HEAT SINK
I.N.	ALUTRONIC	3223-07AC-52	INSULATOR
TB1	AUGAT	GPCR-05-000	CONNECTOR
--	AUGAT	721-0028	BUSHINGS
--	AUGAT	TC6-05-PFH	COVER
J1,2,3	MOLEX	5569-02A1	CONNECTOR
J4	MOLEX	5569-08A1	CONNECTOR
--	MICROMETALS	E162-26	CORE COIL
P.C.B.	--	P.S. CHARGER 150W	--
PN2	P.S.M.	PF632-1	PRESS NUT
--	PHILIPS	4312-20-37250	CORE 3C85
--	PHILIPS	4322-021-33900	MOUNTING PARTS

POWER SUPPLY/CHARGER
15V/10A
MODELS FPN5522A/AA

68P02973G60-A

MOTOROLA INC.
Communications
Sector

VHF TWO-WAY FM RADIO

Model FUD1841AA/AB

136-162 MHz, 25 W

146-174 MHz, 25 W

1. GENERAL

This section is a supplement to the MaxTrac 100/MaxTrac 300 Service Manual (68P80101W76).

The MaxTrac Radio has been modified for operation with the INTRAC 2000 family. Modifications are detailed in paragraph 2.

The specifications of the modified radio are those of the original MaxTrac radio and are included in the above-mentioned service manual. The FCC identification number is ABZ9QCT3733.

2. MODIFICATIONS

2.1 MODEL COMPLEMENTS

A new kit has been defined. Information about the kit breakdown is included in the above-mentioned service manual, except for parts lists FRN5261A and FHN5232A, appended at the end of this section.

NOTE

The model number programmed into the radio EEPROM is D33MJA73A5AK rather than kit number FUD1841AA/AB stamped on the radio label.

FUD1841AA VHF Radio
(25 W, 136-162 MHz)

FHN5232A	Cover
FRN5261A	VHF Conversion Kit
HCN1048A	VHF MaxTrac Mobile Radio
HLN5283A	Label
HUD1705A	Unified Chassis Kit
1280950Y13	Code Plug Programming

FUD1841AB VHF Radio
(25 W, 146-174 MHz)

FHN5232A	Cover
FRN5261A	VHF Conversion Kit
HCN1048A	VHF MaxTrac Mobile Radio
HLN5283A	Label
HUD1706A	Unified Chassis Kit
1280950Y13	Code Plug Programming

2.2 LOGIC BOARD

The Logic Board has been modified as follows (refer to the schematic diagram and circuit board detail):

- A short-circuiting wire has been connected between the collector of transistor Q805 (CSQ) and connector J8-9, thus creating the channel monitor path to the microphone plug.
- A short-circuiting wire has been connected between J8-5 and J8-6, which keeps the radio in continuous standby.

NOTES

- To avoid excessive current drain, the ON/OFF VOLUME knob should usually be switched counter-clockwise until a click is heard. This does not shut the radio off; it only mutes the speaker.
- In order to monitor the channel, turn the ON/OFF VOLUME knob clockwise.

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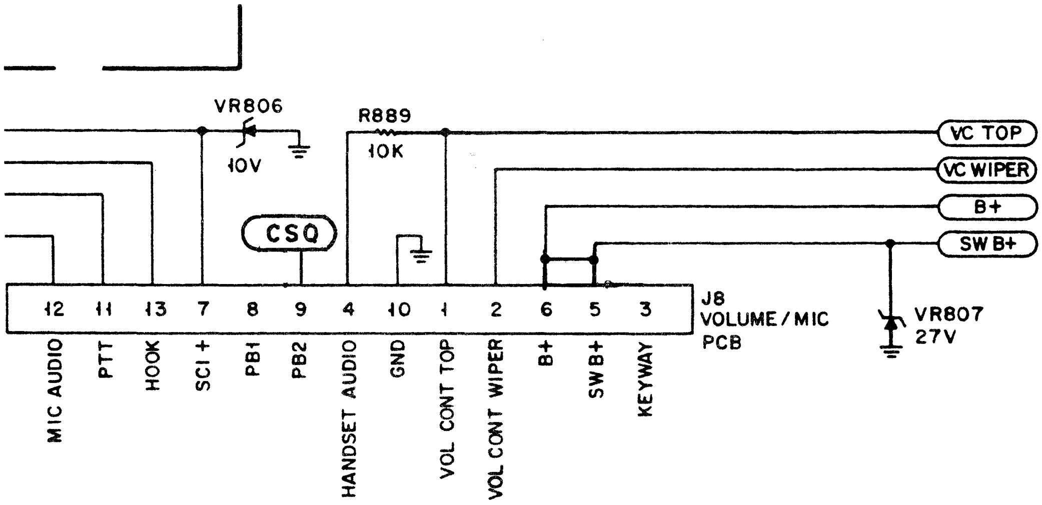

Figure 1. Logic Board Schematic Diagram Detail

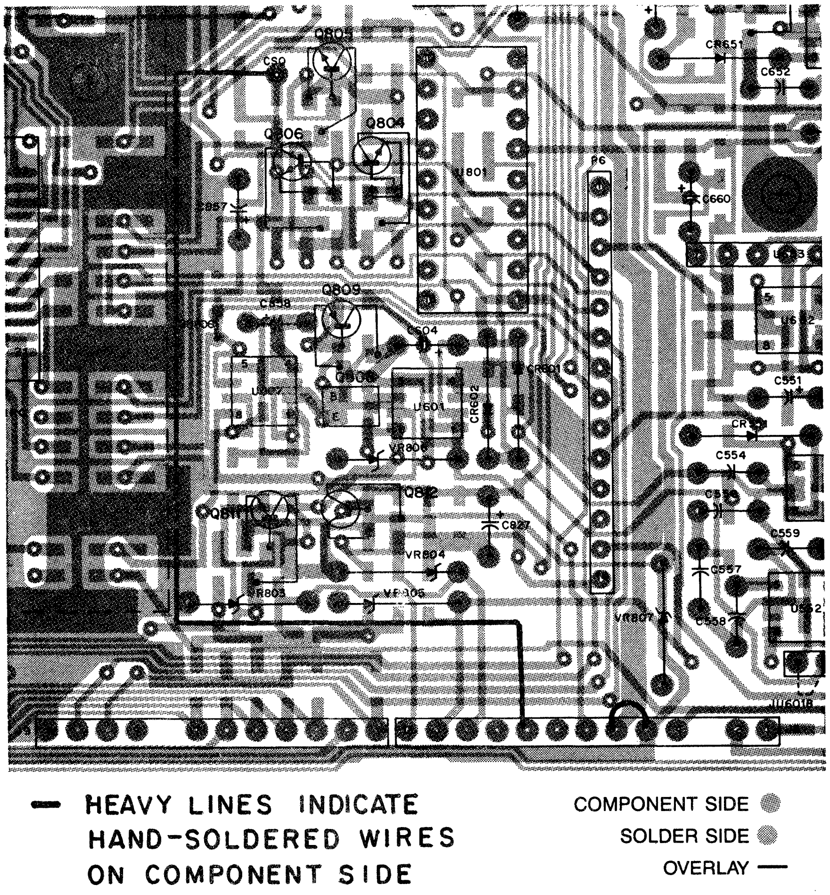

Figure 2. Logic Board Circuit Board Detail

parts lists

FRN5261A VHF Conversion Kit PL-0938-O

Reference Symbol	Motorola Part No.	Description
	Non-referenced items:	
	3010286A72	Wire
	3302721S01	FCC label

FHN5232A Cover PL-0939-O

Reference Symbol	Motorola Part No.	Description
	Non-referenced items:	
	01-80747T30	Speaker cable assembly
	03-10943R55	Screw, 4 used
	03-80270L01	Screw cap, 2 used
	13-00868710	Escutcheon
	15-80127L01	Cover housing, 2 used
	26-80038M01	RF shield, side chassis

MOTOROLA INC.
*Communications
Sector*

UHF TWO-WAY FM RADIO

Model FUE1842AB

450-470 MHz, 25 W

1. GENERAL

This section is a supplement to the MaxTrac 100/MaxTrac 300 Service Manual (68P80101W76).

The MaxTrac Radio has been modified for operation with the INTRAC 2000 family. Modifications are detailed in paragraph 2.

The new radio has a frequency stability of ±2.5 ppm. The radio FCC identification number is ABZ9QCT4737. All other specifications of the modified radio are those of the original MaxTrac radio and are included in the above-mentioned service manual.

2. MODIFICATIONS

2.1 MODEL COMPLEMENTS

A new kit has been defined. Information about the kit breakdown is included in the above-mentioned service manual, except for parts lists FRN5262A and FHN5232A, appended at the end of this section.

NOTE
The model number programmed into the radio EEPROM is D34MJA73A5AK rather than kit number FUE1842AB stamped on the radio label.

FUE1842AB UHF Radio (25 W, 450-470 MHz)	
FHN5232A	Cover
FRN5262A	UHF Conversion Kit
HCN1048A	VHF MaxTrac Mobile Radio
HHN4029A	Housing Kit
HLN5283A	Label
HLN5289A	2-Frequency Escutcheon
HUE2060A	Unified Chassis Kit
1280950Y13	Code Plug Programming

2.2 LOGIC AND RF BOARDS

2.2.1 Logic Board

The Logic Board has been modified as follows (refer to the schematic diagram and circuit board detail):

- A short-circuiting wire has been connected between the collector of transistor Q805 (CSQ) and connector J8-9, thus creating the channel monitor path to the microphone plug.
- A short-circuiting wire has been connected between J8-5 and J8-6, which keeps the radio in continuous standby.
- Three bytes in the software were modified as follows:

From	To
$B65A	$C3
$B65B	$00
$B65C	$0B

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NOTES

- To avoid excessive current drain, the ON/OFF VOLUME knob should usually be switched counter-clockwise until a click is heard. This does not shut the radio off; it only mutes the speaker.

- In order to monitor the channel, turn the ON/OFF VOLUME knob clockwise.

2.2.2 RF Board

The RF Board has been modified as follows:

- R177 was changed to chip resistor, part number 06-11077G18, 18.7k±1%;

- CR176 was changed to zener diode, part number 48-82256C11.

3. ALIGNMENT

After performing the changes mentioned in paragraph 2.2.2, recalibrate the RF Board as detailed in the MaxTrac instruction manual, chapter 12M80953F62, RF Board Test Specifications, section 4.16.

NOTE

- Perform the above-mentioned changes on the Logic and RF Boards whenever they are replaced in the FUE1842AB radio.

- Any board replacement in the FUE1842AB radio erases the software modifications explained in paragraph 2.2.1. The user should reprogram the three bytes according to the modified table.

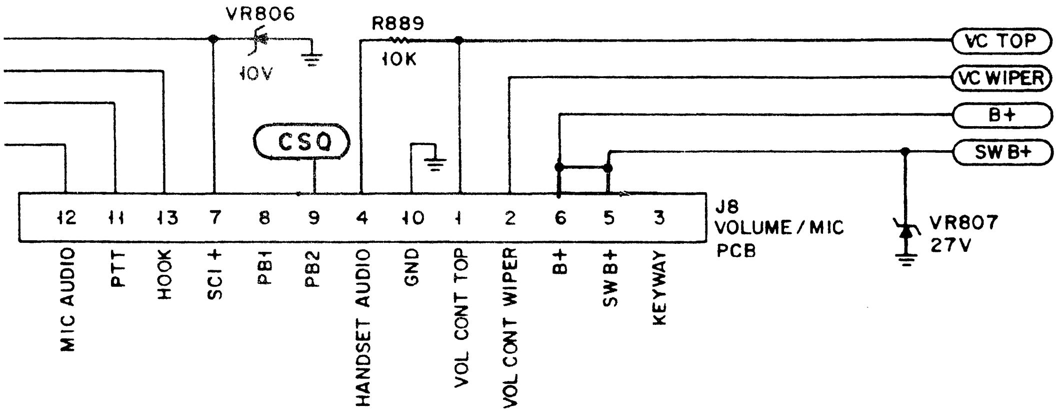
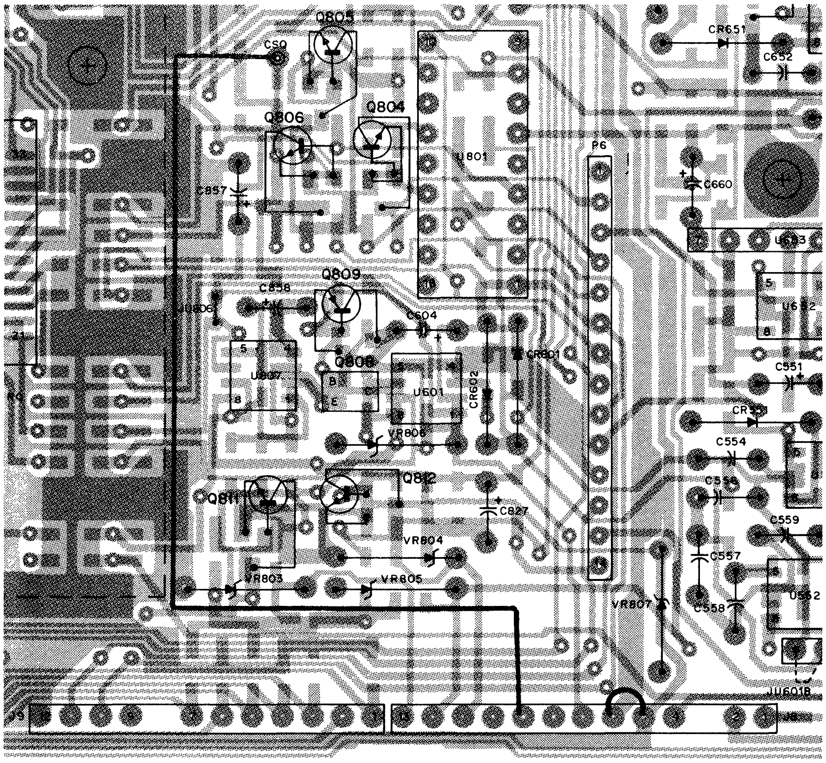


Figure 1. Logic Board Schematic Diagram Detail



— HEAVY LINES INDICATE HAND-SOLDERED WIRES ON COMPONENT SIDE

COMPONENT SIDE ●
SOLDER SIDE ●
OVERLAY —

Figure 2. Logic Board Circuit Board Detail

parts lists

FRN5262A UHF Conversion Kit PL-0956-O

Reference Symbol	Motorola Part No.	Description
	Non-referenced items:	
	06-11077G18	Chip resistor, R177, 18.7k±1%, 1/8 W
	30-10286A72	Wire
	33-02721S01	FCC label
	48-82256C11	Zener diode, 10 V, in place of CR176

FHN5232A Cover PL-0939-O

Reference Symbol	Motorola Part No.	Description
	Non-referenced items:	
	01-80747T30	Speaker cable assembly
	03-10943R55	Screw, 4 used
	03-80270L01	Screw cap, 2 used
	13-00868710	Escutcheon
	15-80127L01	Cover housing, 2 used
	26-80038M01	RF shield, side chassis

MOTOROLA INC.
Communications Sector

UHF TWO-WAY FM RADIO

Model FUE1842AA

403-420 MHz, 25W

1. GENERAL

This section is a supplement to the MaxTrac 100/MaxTrac 300 Service Manual (68P80101W76).

The MaxTrac Radio has been modified for operation with the INTRAC 2000 family. Modifications are detailed in paragraph 2.

The new radio has a 25-W RF power. All other specifications of the modified radio are those of the original MaxTrac radio and are included in the above-mentioned service manual.

2. MODIFICATIONS

2.1 MODEL COMPLEMENTS

A new kit has been defined. Information about the kit breakdown is included in the above-mentioned service manual, except for parts list FEN5535A, appended at the end of this section.

FUE1842AA UHF Radio, 403-420 MHz, 25 W	
FHN5232A	Cover
FEN5535A	UHF Conversion Kit
HCN1048A	VHF MaxTrac Mobile Radio
HHN4029A	Housing Kit
HLN5283A	Label
HLN5289A	2-Frequency Escutcheon
HUE2064B	Unified Chassis Kit
1280950Y13	Code Plug Programming

NOTE

The model number programmed into the radio EEPROM is D44MJA73A5CK rather than kit number FUE1842AA stamped on the radio label.

2.2 LOGIC BOARD

The Logic Board has been modified as follows (refer to the schematic diagram and circuit board detail):

- A short-circuiting wire has been connected between the collector of transistor Q805 (CSQ) and connector J8-9, thus creating the channel monitor path to the microphone plug.
- A short-circuiting wire has been connected between J8-5 and J8-6, which keeps the radio in continuous standby.
- RF power has been adjusted to 25 W.

NOTES

- To avoid excessive current drain, the ON/OFF VOLUME knob should usually be switched counter-clockwise until a click is heard. This does not shut the radio off; it only mutes the speaker.
- In order to monitor the channel, turn the ON/OFF VOLUME knob clockwise.

3. ALIGNMENT

Perform the above-mentioned changes on the Logic Board whenever it is replaced in the FUE1842AA radio. Also reprogram RF power to 25 W.

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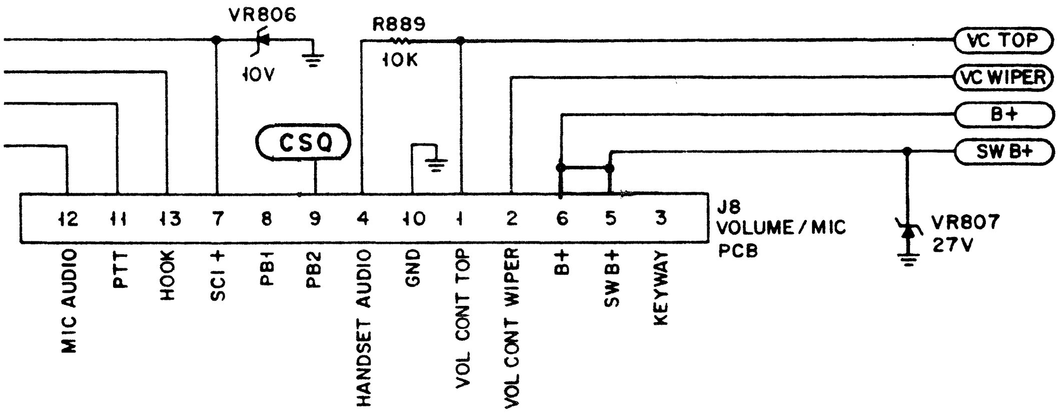

Figure 1. Logic Board Schematic Diagram Detail

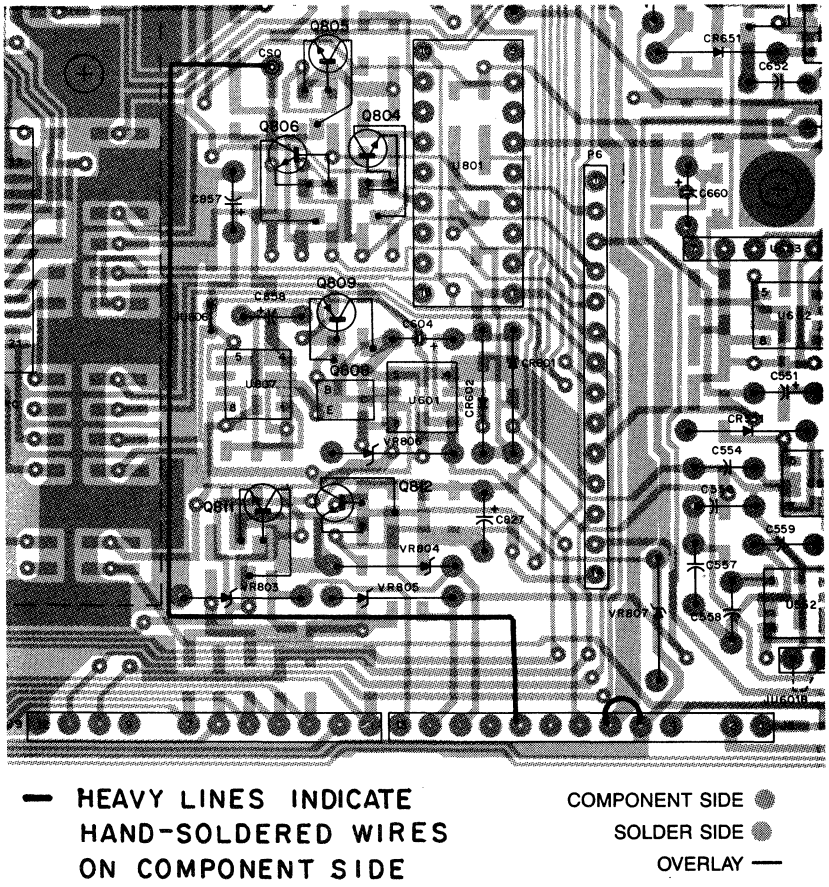

Figure 2. Logic Board Circuit Board Detail

Reference Symbol	Motorola Part No.	Description
	Non-referenced Items:	
	30-10286A72	Wires

MOTOROLA INC.
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MaxTrac™ 800 Series
TRUNKED TWO-WAY FM RADIO
Model FUF1848AA
800 MHz, 15W

1. GENERAL

This section is a supplement to the MaxTrac™ 800 Series Service Manual (68P80900Z01).

The MaxTrac Radio has been modified for operation with the INTRAC 2000 family. Modifications are detailed in paragraph 2.

The specifications of the modified radio are those of the original MaxTrac radio and are included in the above-mentioned service manual.

2. MODIFICATIONS

2.1 MODEL COMPLEMENTS

A new kit has been defined. Information about the kit breakdown is included in the above-mentioned service manual, except for parts lists FRN5263A and FRN4008A, appended at the end of this section.

NOTE
The model number programmed into the radio EEPROM is D35MWA5GB7AK rather than kit number FUF1848AA stamped on the radio label.

FUF1848AA MaxTrac Trunked Two-Way FM Radio (15 W, 800 MHz)

FHN5232A	Cover
FRN5263A	800 MHz Conversion Kit
HCN1043A	Front Panel
HLN5286A	Label
HLN9253A	Escutcheon
FRN4008A	ROM Kit
HUF1041A	Unified Chassis Kit
1280950Y14	Code Plug Programming

2.2 LOGIC BOARD

The Logic Board has been modified as follows (refer to the schematic diagram and circuit board detail):

- A short-circuiting wire has been connected between the collector of transistor Q801 and connector J8-9, thus creating the alarm path to the microphone plug.
- A short-circuiting wire has been connected between J8-5 and J8-6, which keeps the radio in continuous standby.

NOTES
- To avoid excessive current drain, the ON/OFF VOLUME knob should usually be switched counter-clockwise until a click is heard. This does not shut the radio off; it only mutes the speaker.
- In order to monitor the channel, turn the ON/OFF VOLUME knob clockwise.

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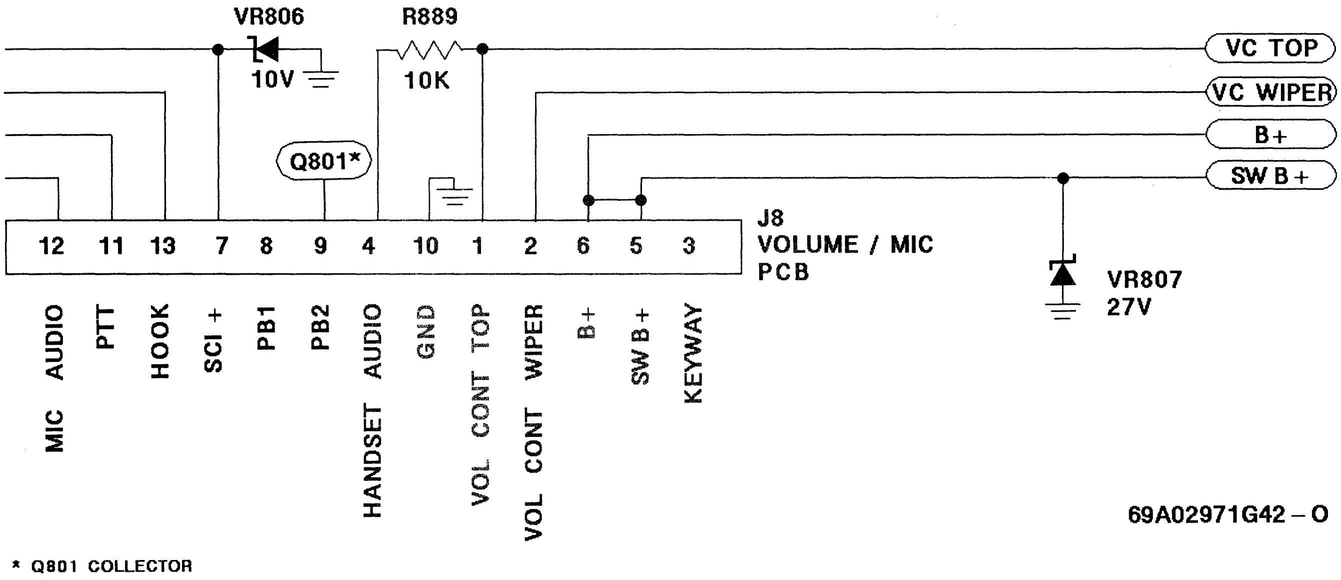


Figure 1. Logic Board Schematic Diagram Detail

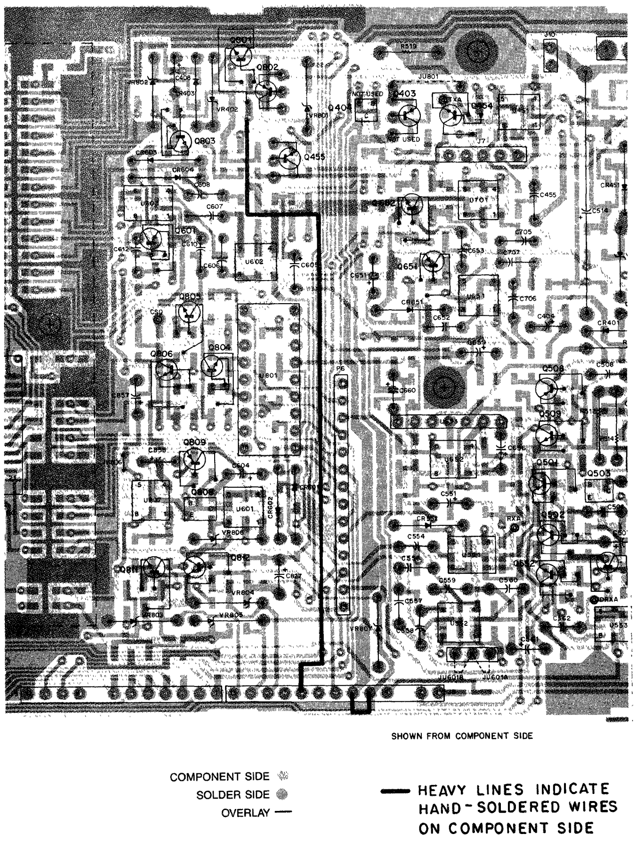

SHOWN FROM COMPONENT SIDE
COMPONENT SIDE
SOLDER SIDE
OVERLAY
HEAVY LINES INDICATE HAND-SOLDERED WIRES ON COMPONENT SIDE

Figure 2. Logic Board Circuit Board Detail

parts lists

FRN5263A Conversion Kit PL-0973-O

Reference Symbol	Motorola Part No.	Description
		Hardware:
	30-10286A72	wiring
	33-02721S03	FCC label

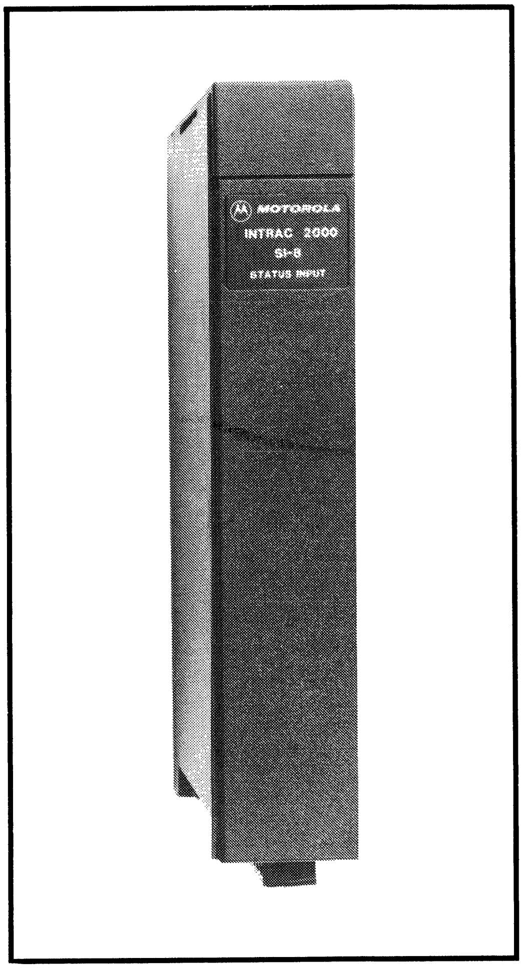
FRN4008A ROM Kit PL-0974-O

Reference Symbol	Motorola Part No.	Description
		Integrated circuit:
	51-02156C50	CMOS, 32kx8

MOTOROLA

INTRAC 2000™

Modular Remote Unit
Status Input



Instruction Manual

68P02938G10-O

COMMERCIAL WARRANTY
(STANDARD)

Motorola radio communications products are warranted to be free from defects in material and workmanship for a period of ONE (1) YEAR, (except for crystals and channel elements, which are warranted for a period of ten (10) years) from the date of shipment. Parts, including crystals and channel elements, will be replaced free of charge for the full warranty period, but the labor to replace defective parts will only be provided for One Hundred-Twenty (120) days from the date of shipment. Thereafter, purchaser must pay for the labor involved in repairing the product or replacing the parts at the prevailing rates together with any transportation charges to or from the place where warranty service is provided. This express warranty is extended by Motorola Communications and Electronics, Inc., 1301 Algonquin Road, Schaumburg, Illinois 60196, to the original purchaser only, and only to those purchasing for purpose of leasing or solely for commercial, industrial, or governmental use.

THIS WARRANTY IS GIVEN IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, WHICH ARE SPECIFICALLY EXCLUDED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL MOTOROLA BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW.

In the event of a defect, malfunction or failure to conform to specification established by SELLER, or if appropriate, to specifications accepted by Seller in writing, during the period shown, Motorola, at its option, will either repair or replace the product or refund the purchase price thereof, and such action on the part of Motorola shall be the full extent of Motorola's liability hereunder.

This warranty is void if:

a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage; and/or
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

The warranty extends only to individual products; batteries are excluded. Because each radio system is unique, Motorola disclaims liability for range, coverage, or operation of the system as a whole under this warranty except by a separate written agreement signed by an officer of Motorola.

LICENSED PROGRAMS: Motorola software provided in connection with this order is warranted to be free from reproducible defects for a period on ONE (1) YEAR. All material and labor to repair any such defects will be provided free of charge for the full warranty period, and SUBJECT TO THE DISCLAIMER IN BOLDFACE TYPE.

Non-Motorola manufactured products are excluded from this warranty, but are subject to the warranty provided by their manufacturers, a copy of which will be supplied to you on specific written request.

In order to obtain performance of this warranty, purchasers must contact their Motorola sales person or Motorola at the address first above shown, attention Quality Assurance Department.

This warranty applies only within the United States.

EPS-30831-O

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EPS-34440-A

MOTOROLA INC.
Communications
Sector

INTRAC 2000™
Modular Remote Unit
Status Input

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Communications
Sector

FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar equipment. The information it contains is current as of the printing date. Subsequent engineering changes are described in supplementary Instruction Manual Revisions (IMRs) issued as needed. The applicable schematic diagram is updated and the changes are described in a revision column printed either on the diagram or next to the corresponding parts list.

2. SERVICE

The Motorola National Service Organization offers one of the finest nationwide installation and maintenance programs available to communications equipment users. This organization comprises approximately 900 Motorola Service Stations located throughout the United States. Each Service Station is independently owned and operated, is staffed by one or more trained, FCC-licensed technicians, and is specially selected and authorized by Motorola.

The administrative staff of the National Service Organization consists of national, area and district service managers, and district representatives, all of whom are Motorola employees. Their objective is continually to improve the service to Motorola customers.

Motorola maintenance is available either on a time and material basis, or by means of a service contract. To obtain a service contract, contact your Motorola Service Representative, or write to:

National Service Manager
Motorola Communications and Electronics Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

3. MODEL AND KIT IDENTIFICATION

Every Motorola product is specifically identified by an overall model number printed on the nameplate. In addition, the assemblies and kits comprising the product usually have kit model numbers stamped on them.

4. REPLACEMENT PARTS ORDERING

Motorola maintains a **factory parts center** and several **area parts centers** located throughout the United States. These facilities are equipped to process parts orders, identify part numbers, and otherwise assist in the maintenance and repair of Motorola Communications Group products. The addresses of these parts centers are listed on the following page.

Orders for crystals, channel elements, active filters, PROMs, code plugs, and resonant reeds should be

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sent directly to the **factory parts center.** Orders for all other parts and for instruction manuals should be sent to the nearest **area parts center.**

All orders for replacement parts or equipment information should include the complete identification number. This requirement applies to all components, kits and chassis. If the component part number is not known, the order should include the number of the chassis or kit which uses it, and a description of the desired component sufficient to identify it.

Orders for crystals and channel elements should specify the crystal or channel element type number, crystal and carrier frequencies, and the model number of the chassis using the part.

Orders for active filters, PROMs, code plugs, and "Vibrasender" and "Vibrasponder" resonant reeds, should specify type number and frequency, and should identify the owner/operator of the communications system utilizing these items.

5. ADDRESSES

5.1 AREA PARTS CENTERS

5.1.1 U.S. Orders

Western Area Parts
1170 Chess Drive, Foster City
San Mateo, California 94404
Telephone: 415-349-3111
TWX: 910-375-3877

Midwest Area Parts
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-7322
TWX: 910-693-0869

Mid-Atlantic Area Parts
7230 Parkway Drive
Hanover, Maryland 20176
Telephone: 301-796-8600
TWX: 710-862-1941

East Central Area Parts
12995 Snow Road
Parma, Ohio 44130
Telephone: 216-267-2210
TWX: 810-421-8845

Eastern Area Parts
85 Harristown Road
Glen Rock, New Jersey 07452
Telephones: 201-447-4000
TWX: 710-988-5602

Pacific Southwestern Area Parts
P.O. Box 85036
San Diego, California 92138
Telephone: 714-578-2222
TWX: 910-335-1634

Gulf States Area Parts
8550 Katy Freeway, Suite 128
Houston, Texas 77024
Telephone: 713-932-8955

Southwestern Area Parts
P.O. Box 34290
3320 Belt Line Road
Dallas, Texas 75234
Telephone: 214-241-2151
TWX: 910-860-5505

Southeastern Area Parts
P.O. Box 368
Decatur, Georgia 30031
Telephone: 504-981-9800
TWX: 810-766-0876

5.1.2 Canadian Orders

Motorola Ltd.
National Parts Department
3125 Steeles Avenue
E. Willowdale, Ontario M2H 2H6
Telephone: 416-499-1441
TWX: 610-492-2713
Telex: 065-25191

5.1.3 All Other Countries

Motorola Inc., or
Motorola Americas, Inc.
International Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
U.S.A.
Telephone: 312-576-6492
TWX: 910-693-0869
Telex: 722443 or 722424
Cable: MOTOL PARTS

5.2 FACTORY PARTS CENTER

5.2.1 Mail Orders

Motorola, Inc.
Component Products Sales and Service
P.O. Box 66191
O'Hare International Airport
Chicago, Illinois 60666

5.2.2 Other Correspondence

Motorola, Inc.
Component Products Sales and Service
2553 N. Edgington Street
Franklin Park, Illinois 60131

5.3 GENERAL OFFICES

Motorola Communications and Electronics Inc.
Communications Group Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-3900

KIT BREAKDOWN

FLN1462A Status Input Module (SI-8)

- FLN4368A Main Board
- FLN4449A EPROM Kit
- FLN4450A Label Kit
- FLN5720A Hardware Kit
- FLN4347A Modular Housing

PERFORMANCE SPECIFICATIONS

GENERAL

Voltage Input	11-15 V dc through the MRU bus.
Operating Temperature	-30°C to +60°C.
Relative Humidity	0-90% without condensation.
Weight	14.5 oz. (0.412 kg)
Dimensions	1.6" X 8.3" X 3.7" (W x H x D) 40.64 X 210.82 X 93.98mm Height with open door 11.6".
Housing	Thermo-plastic module.
Input Connections	Screw type terminal strip.
Status Report to MRU Encoder	Activated by any of the following: - change-of-state (COS) - interrogation - local test function.
Status Inputs	Up to 12, dry contact Closed < 3k ohms (0.2mA typical current) Open > 40k ohms.
COS Detection	Contact closing or contact opening.
Minimum duration of new input for COS detection	30 ms.
Parameterization	On PC Board DIP switches.
Communication	With MRU Encoder via the MRU-bus.
Surge Protection	2.5 kV (IEEE 472 Standard).
Current Consumption	8.5 mA (+ 250 microampere per input when closed).

MOTOROLA INC.
Communications
Sector

SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.
2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.
3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.
5. Use only a grounded soldering iron.
6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

   WARNING

   If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.

MOTOROLA INC.

Communications
Sector

GENERAL DESCRIPTION

The Status Input Module (SI-8) is an expansion module which provides additional status inputs to the 8 discrete inputs included in the Encoder (ES-8) of the basic MRU.

Up to 56 discrete inputs (total MRU discrete input capacity is 64) contained in seven SI-8 modules may be added. Each SI-8 module contains 12 (8+4) discrete inputs (see Table 1 Input Capacity Combinations). They are reported in seven groups (B-H), with eight discrete inputs to the first group and four discrete inputs to the consecutive group.

The first eight discrete inputs are reported (assigned) in one group address.

The second group (four discrete inputs, input 9 to input 12) is automatically assigned to the consecutive group address. For example, if the first eight discrete status inputs are reported on group address B, then the remaining four discrete status inputs are automatically reported (assigned) in group address C.

NOTE

The second group of four discrete inputs input 9 to input 12 is factory supplied in disabled mode.

The SI-8 module may be ordered either as an option (V115AA) or as an accessory (FLN1462).

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Table 1. Input Capacity Combinations

NUMBER OF INPUTS		NUMBER OF MODULES	
Status Inputs including ES-8	Maximum Analog Inputs	Status SI-8	Analog AI-6***
1-8 (ES-8)	6	0	1
9-16	6	1	1
9-20	5	1*	1**
17-24	5	2	1**
17-28	4	2*	1**
25-32	4	3	1**
25-36	3	3*	1**
33-40	3	4	1**
33-44	2	4*	1**
41-48	2	5	1**
41-52	1	5*	1**
49-56	1	6	1**
49-60	0	6*	0
57-64	0	7	0

* The additional four discrete inputs are automatically assigned to the consecutive group address.

** Some of the analog inputs are masked (when 17-56 status inputs are required).

*** Applicable also to future input types, such as counters.

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Communications Sector

INSTALLATION

1. PRELIMINARY

Carefully inspect the SI-8 module immediately upon receipt and notify the shipper of any damage that has ocurred in transit. The installation procedure consists of mounting the housing and making the necessary external and internal electrical connections.

2. DISASSEMBLY

To access either jumpers or switches, the SI-8 module must be disassembled. Follow the directions below for proper disassembly of the SI-8 module housing (refer to Figure 2. Disassembly).

Step 1. Lift the latch door located at the top of the housing.

Step 2. Disconnect the MRU bus flat cable.

Step 3. Loosen the two captive screws which hold the module to the mounting plate (not visible).

Step 4. Loosen the two captive screws on the right panel of the SI-8 module housing.

Step 5. Assure that the latch door is open.

Step 6. Gently separate the two sides, exposing the printed circuit board (PCB).

3. PARAMETER DESCRIPTION
(SWITCH POSITION)

NOTE
The SI-8 module will read the switches only upon power-up, or test activation.

Switches 1-3, 1-2, 1-1:
Select the first group of 8 discrete inputs (input 1 to input 8). Refer to Table 1. Group Selection.

Switch 1-4:
Enables/disables the second group of discrete inputs (input 9 to input 12). In the enable mode (S1-4 open) the second group is activated and automatically assigned to the group address following the first group. In the disable mode the specific discrete inputs are not activated.

NOTE
The second group of discrete inputs is factory supplied in the disable mode.

Switch 1-5:
Masks/unmasks the first and second groups. In the mask mode (S1-5 open) the messages are transmitted in response to interrogation only. In the unmask mode (S1-5 closed) the messages are transmitted automatically upon change-of-state (COS) and/or in response to interrogation.

Switches 1-6, 1-7, 1-8:
Reserved.

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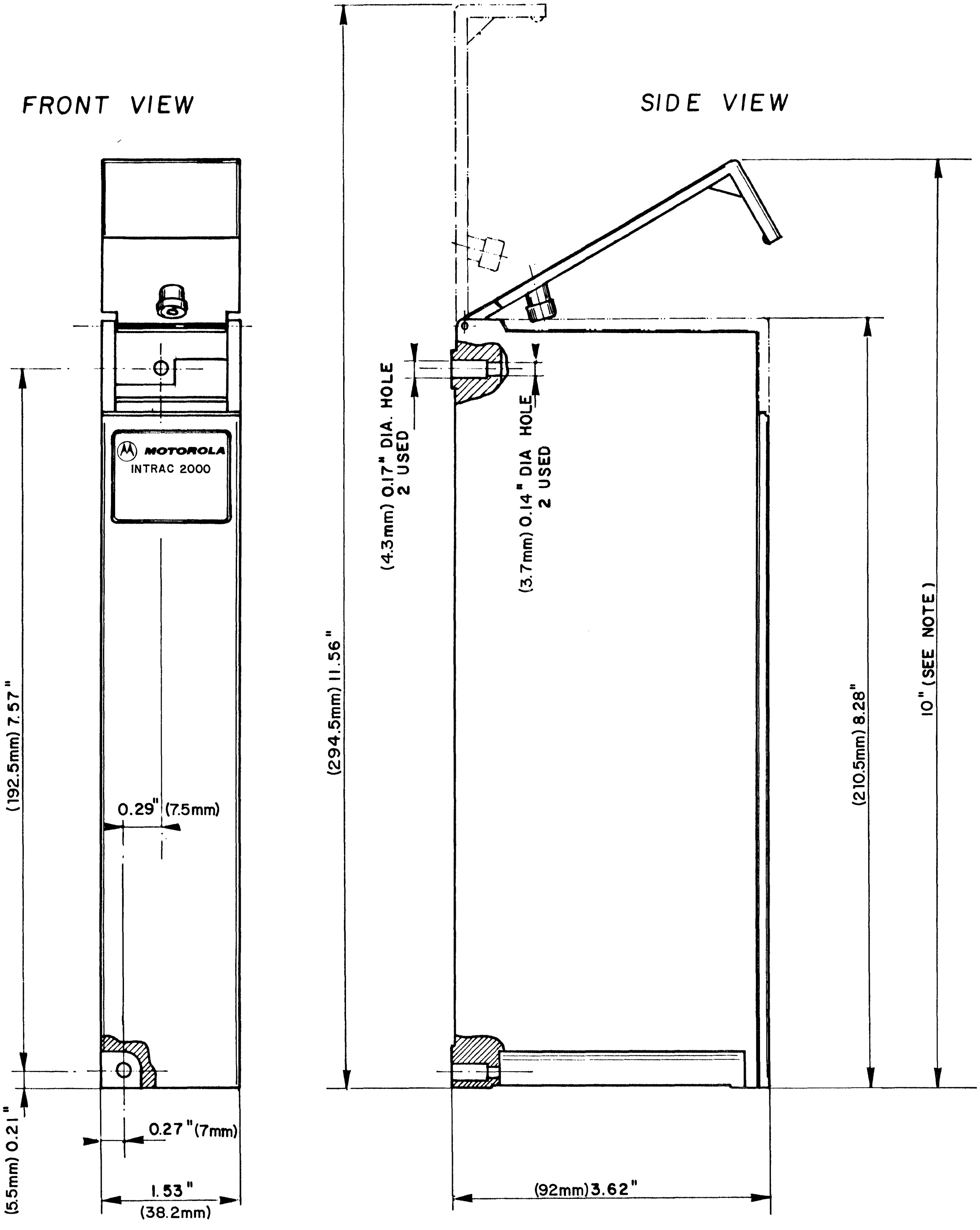
FRONT VIEW

SIDE VIEW



NOTE

MINIMUM OPENING FOR REMOVING
WIRE CONNECTOR.

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Figure 1. Housing Detail

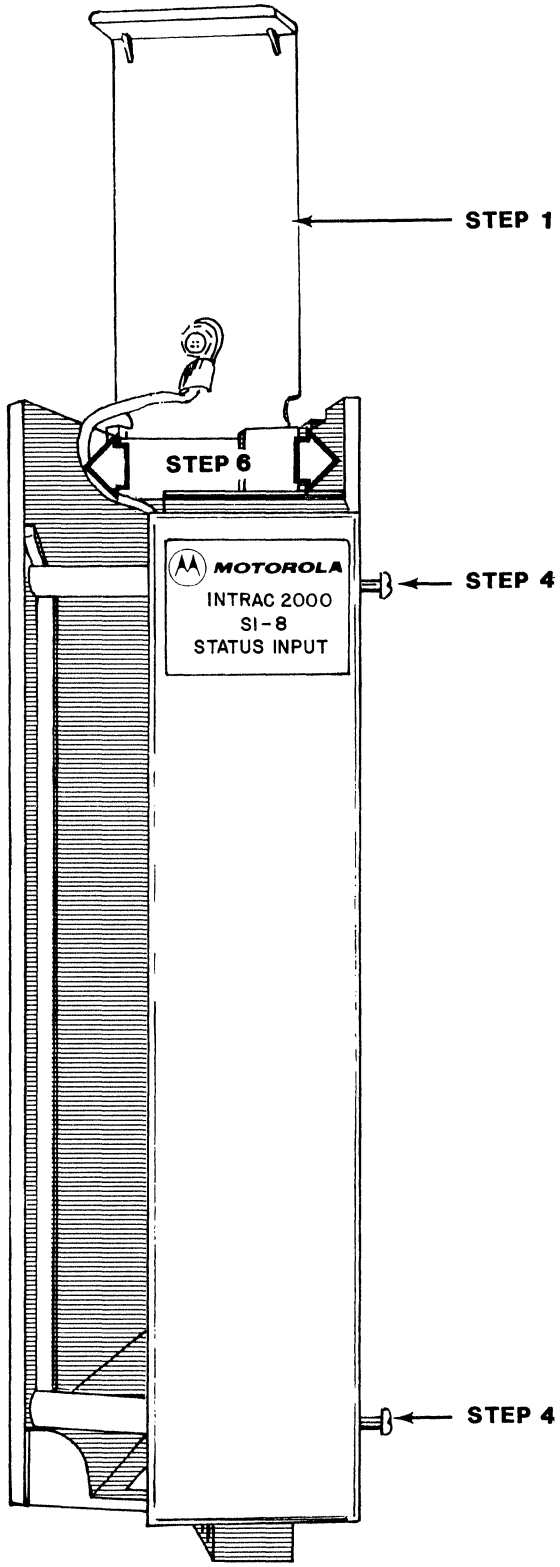

Figure 2. Disassembly

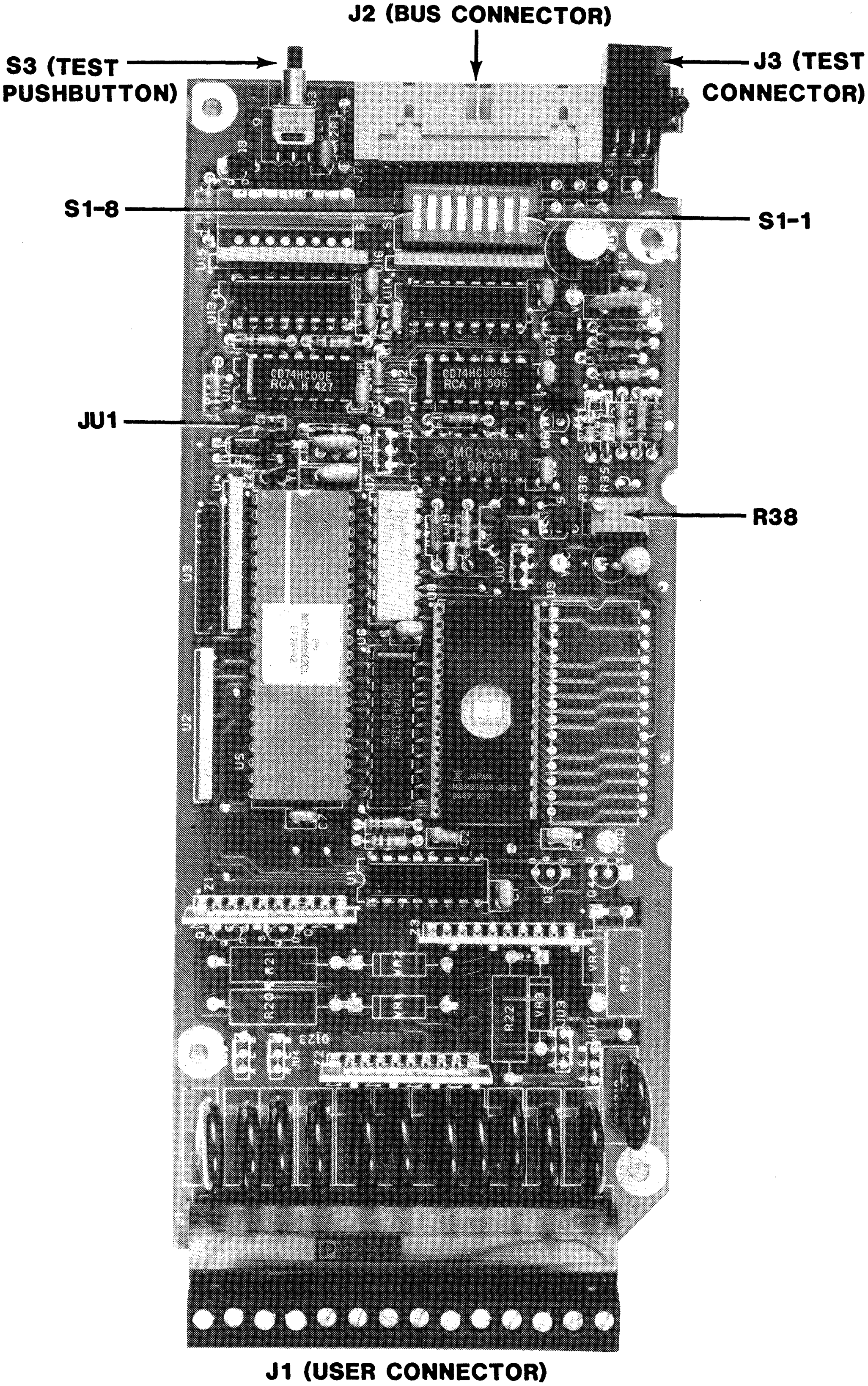

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Figure 3. Printed Circuit Board

Table 1. Group Selection

Switch Position			Group Designation	
S1-3	S1-2	S1-1	First Group	Second Group
0	0	0	-	B
0	0	1	B	C
0	1	0	C	D
0	1	1	D	E
1	0	0	E	F
1	0	1	F	G
1	1	0	G	H
1	1	1	H	B

Remarks:

a. Open = 1, Closed = 0

b. Group A is assigned to the Encoder module, therefore it is not available in the SI-8 module.

c. Care should be taken that switches S1-1,2,3,4 are not assigned groups that have already been assigned in other modules.

4. JUMPERS

JU1 - Watchdog Timer:
Connected - enabled, (normal operation)
Disconnected - disabled.

JU2, JU7:
Fixed (should not be changed for normal operation).

5. MOUNTING

Mount the SI-8 module next to the other MRU modules with the two captive screws (included with the module) then connect the MRU bus flat cable to the bus user connector of the SI-8 module.

The connection between the SI-8 and the MRU Encoder (ES-8) is via a 26 pin flat cable connected to the bus connector J2 on the SI-8 module. In order to insert the cable connector correctly to J2, the user must match the triangular sign on the male and female connectors (the triangular sign on the cable connector is on the same side as the red painted wire on the cable).

6. CONNECTIONS

6.1 EXTERNAL CONNECTIONS

All electrical cables should be consistent with mounting location environment and should conform to applicable electrical codes.

Use weatherproof cable entrance hardware and proper external housing for outdoor installation.

For approved fire and security installations, refer to applicable regulation such as NEPA72D or other local requirements.

Table 2. User Connector Input Connections

User Input No.	Status Input	Bit Number in INTRAC Word	Group
1	IN 9	23	Second
2	IN 10	22	Second
3	IN 1	23	First
4	IN 2	22	First
5	IN 3	21	First
6	IN 4	20	First
7	GND	--	---
8	IN 5	19	First
9	IN 6	18	First
10	IN 7	17	First
11	IN 8	16	First
12	GND	--	---
13	IN 11	21	Second
14	IN 12	20	Second

6.2 USER INPUT CONNECTIONS

The status inputs are single-ended and are referenced to ground. The external circuits connected to these inputs should consist of dry contacts. The inputs recognize an external resistance of less than approximately 3k ohms as a closed circuit, and an external resistance of greater than approximately 40k ohms as an open circuit.

The SI-8 supplies only a few hundred microamperes of current to the external contacts.

The status inputs are located on the user connector terminal strip, (see Table 2, User Connector Input Connections).

NOTE

The SI-8 circuit ground (terminals 7 and 12) are the common return terminal for the status inputs. To avoid udesirable ground loops, the input returns should be connected to one or both of these terminals and must not be grounded elsewhere.

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Communications Sector

THEORY OF OPERATION

1. GENERAL

The Status Input (SI-8) PC Board is based on the MC146805E2 CMOS microprocessor. It contains the following circuits:

- Processing Unit
- Input Sensing and Surge Protection
- 5 V Regulator
- Bus Interface
- Watchdog Timer
- External Connectors

2. CIRCUITS DESCRIPTION

2.1 PROCESSING UNIT

The processing unit consists of the MC146805E2 microprocessor (U5), EPROM (U8), address latch (U6), RAM (U9, not used) and memory mapping (U11, U12, JU6 and JU7).

2.2 INPUT SENSING AND SURGE PROTECTION

Twelve dry-contact inputs are located on user connector JI. They are sensed (on the average) every 30 ms. COS is determined by the microprocessor software. The minimum time for COS detection is 30 ms. The protection circuit consists of varistors VZ1-VZ12 and hybrids Z1-Z3.

2.3 5 V REGULATOR

The purpose of the 5 V voltage regulator circuit is to regulate the input voltage to 5 V dc in order to supply proper voltage to the logic circuits. The regulator has a low standby current of 80 uA. The voltage output is temperature compensated and is accurate to better than ±5%. The regulator is current limited and prevents the CMOS logic from entering SCR mode by using a fold-back current limiter technique.

2.4 BUS INTERFACE

The bus interface consists of six lines which are connected to the I/O ports of the microprocessor through series protection resistors (U7) and pull up resistors (U4) (see Table 1, Microprocessor Port Bus Connector).

Table 1.Microprocessor Port Bus Connector

Port	Function
PB6	READY
PB0	DATA
PB5	BUSY
IRQ	BUSY
PB4	CK
PB3	ADDR
PB7	BREQ

The bus provides two way communication, to and from the SI-8.

a. The SI-8 receives messages when:

- The Decoder has received an interrogation message.

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- The test button on the Decoder is activated.

- The test function of the Encoder is activated.

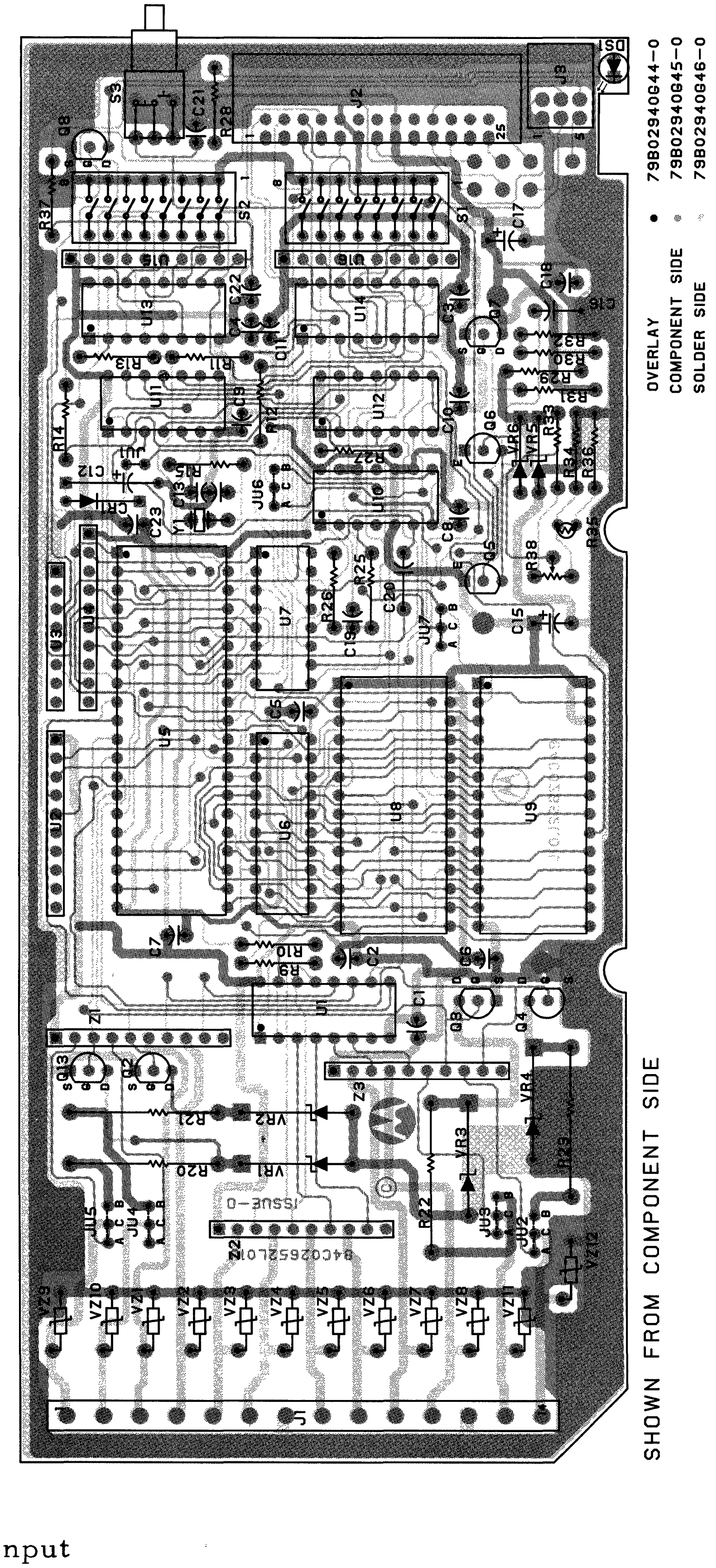
- The Encoder periodic timer has finished its cycle.

b. The SI-8 requests transmission due to a COS or when the module test function is activated.

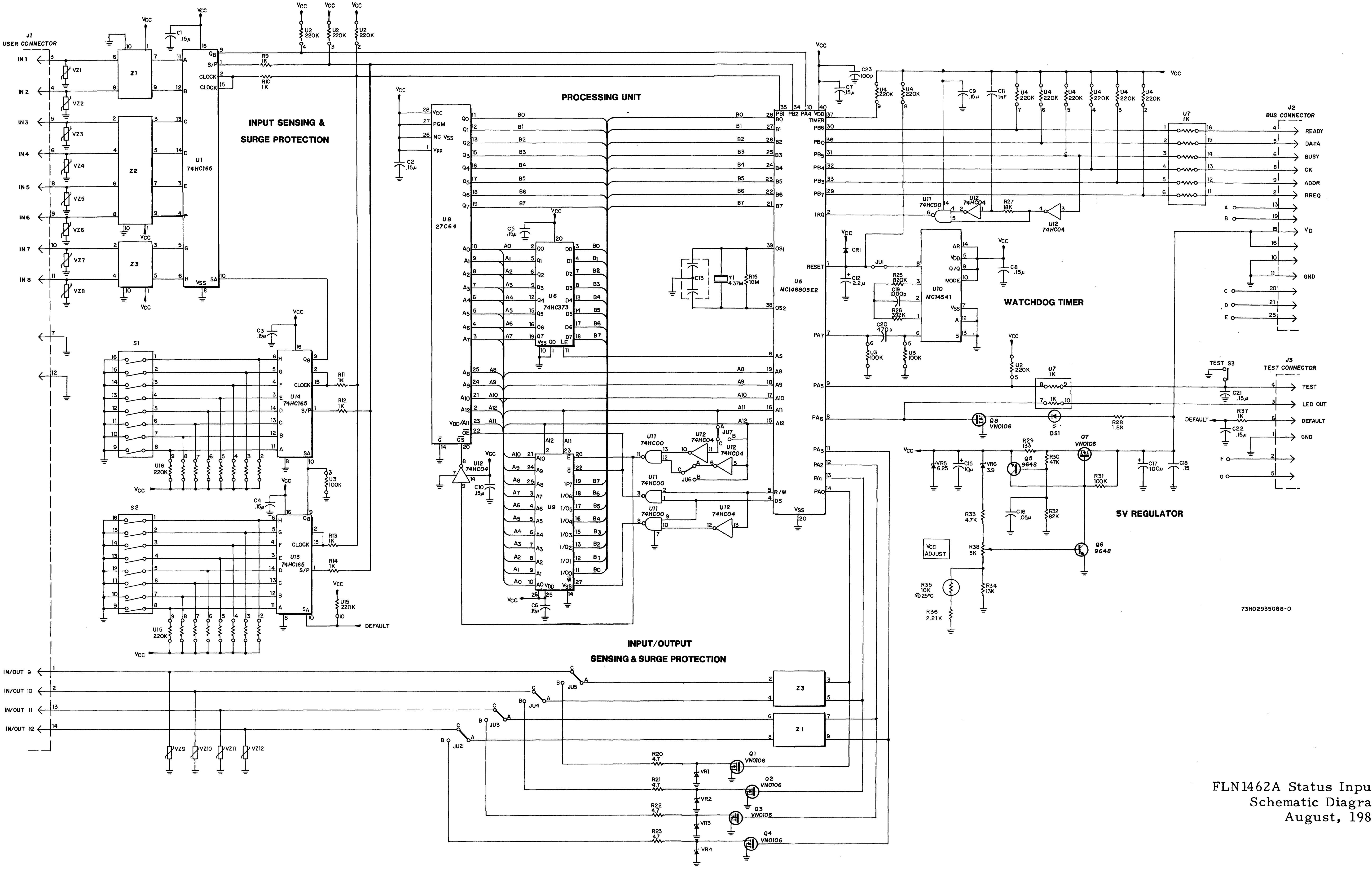
2.5 WATCHDOG TIMER

The watchdog timer circuit is used to prevent program runaway. It has an autonomous oscillator/timer (U10, R25, C19, R26). The circuit is designed to set its output approximately 3.5 sec. after being reset. If the time period elapses, U10 pin 8 will go low and a reset to the microprocessor will be generated.

Under normal conditions, the microprocessor periodically executes a code, which in turn, generates a reset pulse. The pulse resets the timer (U10 pin 6) through C20. In this case, U10 is normally high since it is reset by the microprocessor before the 3.5 sec. period expires. However, if the program runs away, there is a good chance that the microprocessor will not execute the short sequence of instructions that generate the reset pulse to the watchdog timer. The timer will continue to count freely and, when 3.5 sec. have elapsed, it will generate a reset pulse to the microprocessor. The microprocessor will then initiate a software reset to the system.


OVERLAY ● 79B02940G44-0
COMPONENT SIDE 79B02940G45-0
SOLDER SIDE 79B02940G46-0
SHOWN FROM COMPONENT SIDE
84C02652L01
ISSUE-0

FLN1462A Status Input
Printed Circuit Board Detail
August, 1986



FLN1462A Status Input
Schematic Diagram
August, 1986

parts lists

FLN4368A Status Input Board PL-0379-O

Reference Symbol	Motorola Part No.	Description
		Capacitor fixed: uF unless otherwise stated
C1 thru 10	21-84008H03	0.15
C11	21-83162H09	1 nF ±5% N150
C12	23-84762H04	2.2
C13	-----	part of Y1
C14	-----	Not used
C15	23-84538G10	10, 20 V
C16	21-82372C04	0.05 -20+80%, 25 V
C17	23-02166L06	100
C18	21-84008H03	0.15
C19	21-83162H09	1 nF ±5%
C20	21-82428B51	470 pF ±5%, 200 V
C21	21-84008H03	0.15
C22	21-84008H03	0.15
C23	21-05455G01	100 pF 50 V
		Diode
CR1	48-11034A01	Signal HO1
		LED
DS1	48-84404E03	Red LED
		Connector
J1	28-08508G04	14-pin user connector PC
J2	28-08044H06	26-pin bus connector
J3	28-08514G02	6-pin test connector
		Transistor
Q1 thru 4	----	Not used
Q5, Q6	48-00869648	M9648, NPN type
Q7, Q8	48-08237G05	VN0106N3 VMOS
		Resistor fixed: ±5% unless otherwise noted
R1 thru 8	----	Not used
R9 thru 14	06-11009C49	1 k
R15	06-00124B46	10 M
R16 thru 24	----	Not used
R25	06-11009D20	820 k
R26	06-10621E46	392 k, 1%
R27	06-11009C79	18 k
R28	06-11009C55	1.8 k
R29	06-10621B10	133, 1%
R30	06-11009C89	47 k
R31	06-11009C97	100 k
R32	06-11009C95	82 k
R33	06-11009C65	4.7 k
R34	06-11009C76	13 k
R35	06-83600K06	10 k, at 25°C
R36	06-10621C28	2.21 k, 1%
R37	06-11009C49	1 k
R38	18-02467C21	Potentiometer 5 k
		Switches
S1	40-83849F02	DIP switch, 8 switches
S2	----	Not used
S3	40-08242G01	Momentary pushbutton
		Integrated Circuit
U1	51-08244G53	74HC165N
U2	51-02599K14	Resistor network 9 X 220k SIP
U3	51-02599K12	Resistor network 7 X 100k SIP
U4	51-02599K14	Resistor network 9 X 220k SIP
U5	51-02187C28	MC146805E2CP
U6	51-08244G34	74HC373N
U7	51-02150C05	Resistor network 8 X 1k
U8	51-02156C37	27C64, (FLN4449A)
U9	----	Not used
U10	51-02073C39	MC14541BCL
U11	51-08244G04	74HC00N
U12	51-08244G08	74H04
U13, U14	51-08244G53	74HC165N
U15, U16	51-02599K14	Resistor network 9 X 220k SIP
		Zener Diode
VR5	48-83461E36	6.2 V, IN4735A
VR6	48-02064C82	3.9 V 50 uA 250 mW
		Varistor
VZ1 thru 12	06-02597K06	MOV, 45 V, V56ZA8
		Crystal
Y1	48-08565C02	4.37 MHz Resonator including capacitor
		Hybrid
Z1 thru Z3	51-08404H01	Input Sensing and Surge Protection
	Non-Referenced Items	
	84-02652L01	Printed Circuit Board
	09-02134C06	IC socket 40-pin, for U5
	09-02134C07	IC socket 28-pin, for U8
JU1	28-02218K12	2-pin for mini-jumper
JU1	29-02219K01	mini-jumper

FLN4347A Housing PL-0380-O

Reference Symbol	Motorola Part No.	Description
	02-02427C01	Lock nut 4X40, 1 used
	03-08026H05	Cap scr 8X32 7/8", 2 used
	03-82210E15	Captive screw, 2 used
	15-08513H01	Housing bottom, 1 used
	15-08586G01	Housing cover, 1 used
	15-08587G01	Door box, 1 used
	22-02482C02	Dowel pin, 1 used

FLN5720A Hardware Kit PL-0381-O

Reference Symbol	Motorola Part No.	Description
	01-02717G06	Terminal & wire, 1 used
	03-00129675	Lock scr 4x40x1/4 2 used
	03-00134309	Lock scr 4x40x3/16 1 used
	31-08509G04	14-pin user conn 1 used
	54-08125H01	Connector label, 1 used

FLN4450A Label Kit PL-0382-O

Reference Symbol	Motorola Part No.	Description
	54-02243L01	FCC Label
	54-08635G08	Front panel label
	54-08124H07	Add label

Note: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

MAINTENANCE

1. DISASSEMBLY

Refer to the disassembly instructions located in the Installation section of this manual.

1.1 VCC ADJUSTMENT

Attach the positive terminal of a voltmeter to the cathode (+) of VR5 and the negative (-) terminal to the anode of VR5. Adjust potentiometer R38 so that the meter reading is 5 V (±0.1 V).

1.2 JUMPERS

JU1 Watchdog Timer:
Connected - enabled (normal operation)
Disconnected - disabled.

JU2-JU7:
Are fixed and should not be changed for normal operation.

1.3 PARAMETER DESCRIPTION (SWITCH POSITION)

NOTE
The SI-8 module will read the switches only upon power-up, or test activation.

Switches 1-3, 1-2, 1-1:
Select the first group of 8 discrete inputs (input 1 to input 8). Refer to Table 1. Group Selection.

Switch 1-4:
Enables/disables the second group of discrete inputs (input 9 to input 12). In the enable mode (S1-4 open), the second group is activated and automatically assigned to the group address following the first group. In the disable mode, specific discrete inputs are not activated.

NOTE
The second group of discrete inputs is factory supplied in the disable mode.

Switch 1-5:
Masks/unmasks the first and second groups. In the mask mode (S1-5 open) the messages are transmitted in response to interrogation only. In the unmask mode (S1-5 closed) the messages are transmitted automatically upon change-of-state (COS) and/or in response to interrogation.

Switches 1-6, 1-7, 1-8:
Reserved.

2. SI-8 SELF-TEST AND DIAGNOSTICS

An easy-to-use tool for diagnostics and self-test is available.

The self-diagnostics LED presents the result of the self-test by a number of flashes (see Table 2 LED Indication).

The diagnostics function is activated by a pushbutton or by the test connector (J3 pin 4) connected to ground momentarily. The LED also flashes at power-on.

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Table 1. Group Selection

Switch Position			Group Designation	
S1-3	S1-2	S1-1	First Group	Second Group
0	0	0	-	B
0	0	1	B	C
0	1	0	C	D
0	1	1	D	E
1	0	0	E	F
1	0	1	F	G
1	1	0	G	H
1	1	1	H	B

Remarks:

a. Open = 1, Closed = 0

b. Group A is assigned to the Encoder module, therefore it is not available in the SI-8 module.

c. Care should be taken that switches S1-1,2,3,4 are not assigned groups that have already been assigned in other modules.

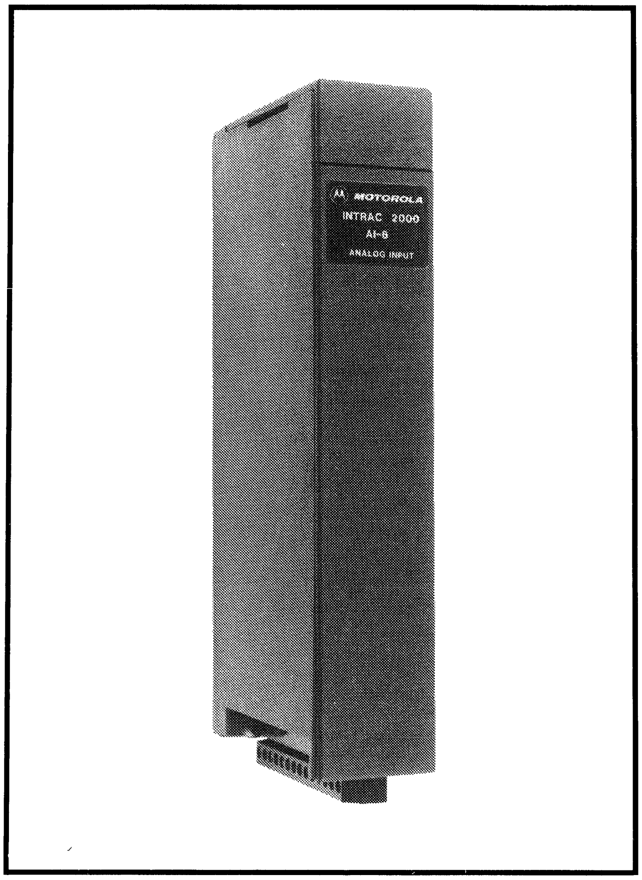
Table 2. LED Indication, Detailed Diagnostic

Number of Flashes	Diagnostic	Corrective Action/ Failure Description
No flashes LED off	Power	Check power or LED failure and/or replace flat cable
No flashes LED on	Defective EPROM or microproccesor	Replace EPROM and/or microprocessor
Two flashes	Normal Operation	
Three flashes	SI-8/ES-8 interface failure	Check parameter conflict or replace SI-8 and/or replace ES-8 and/or replace flat cable
Four flashes	Microprocessor failure	Replace microprocessor
Five flashes	EPROM failure	Replace EPROM
Six flashes	Software failure	Reset the SI-8 by power disconnection

MOTOROLA

INTRAC 2000™

Modular Remote Unit
Analog Input



Instruction Manual

68P02933G40-0

COMMERCIAL WARRANTY
(STANDARD)

Motorola radio communications products are warranted to be free from defects in material and workmanship for a period of ONE (1) YEAR, (except for crystals and channel elements, which are warranted for a period of ten (10) years) from the date of shipment. Parts, including crystals and channel elements, will be replaced free of charge for the full warranty period, but the labor to replace defective parts will only be provided for One Hundred-Twenty (120) days from the date of shipment. Thereafter, purchaser must pay for the labor involved in repairing the product or replacing the parts at the prevailing rates together with any transportation charges to or from the place where warranty service is provided. This express warranty is extended by Motorola Communications and Electronics, Inc., 1301 Algonquin Road, Schaumburg, Illinois 60196, to the original purchaser only, and only to those purchasing for purpose of leasing or solely for commercial, industrial, or governmental use.

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In the event of a defect, malfunction or failure to conform to specification established by SELLER, or if appropriate, to specifications accepted by Seller in writing, during the period shown, Motorola, at its option, will either repair or replace the product or refund the purchase price thereof, and such action on the part of Motorola shall be the full extent of Motorola's liability hereunder.

This warranty is void if:

a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage; and/or
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

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MOTOROLA INC.
Communications
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INTRAC 2000™
Modular Remote Unit
Analog Input

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FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar equipment. The information it contains is current as of the printing date. Subsequent engineering changes are described in supplementary Instruction Manual Revisions (IMRs) issued as needed. The applicable schematic diagram is updated and the changes are described in a revision column printed either on the diagram or next to the corresponding parts list.

2. SERVICE

The Motorola National Service Organization offers one of the finest nationwide installation and maintenance programs available to communications equipment users. This organization comprises approximately 900 Motorola Service Stations located throughout the United States. Each Service Station is independently owned and operated, is staffed by one or more trained, FCC-licensed technicians, and is specially selected and authorized by Motorola.

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National Service Manager
Motorola Communications and Electronics Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

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Every Motorola product is specifically identified by an overall model number printed on the nameplate. In addition, the assemblies and kits comprising the product usually have kit model numbers stamped on them.

4. REPLACEMENT PARTS ORDERING

Motorola maintains a **factory parts center** and several **area parts centers** located throughout the United States. These facilities are equipped to process parts orders, identify part numbers, and otherwise assist in the maintenance and repair of Motorola Communications Group products. The addresses of these parts centers are listed on the following page.

Orders for crystals, channel elements, active filters, PROMs, code plugs, and resonant reeds should be

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sent directly to the **factory parts center.** Orders for all other parts and for instruction manuals should be sent to the nearest **area parts center.**

All orders for replacement parts or equipment information should include the complete identification number. This requirement applies to all components, kits and chassis. If the component part number is not known, the order should include the number of the chassis or kit which uses it, and a description of the desired component sufficient to identify it.

Orders for crystals and channel elements should specify the crystal or channel element type number, crystal and carrier frequencies, and the model number of the chassis using the part.

Orders for active filters, PROMs, code plugs, and "Vibrasender" and "Vibrasponder" resonant reeds, should specify type number and frequency, and should identify the owner/operator of the communications system utilizing these items.

5. ADDRESSES

5.1 AREA PARTS CENTERS

5.1.1 U.S. Orders

Western Area Parts
1170 Chess Drive, Foster City
San Mateo, California 94404
Telephone: 415-349-3111
TWX: 910-375-3877

Midwest Area Parts
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-7322
TWX: 910-693-0869

Mid-Atlantic Area Parts
7230 Parkway Drive
Hanover, Maryland 20176
Telephone: 301-796-8600
TWX: 710-862-1941

East Central Area Parts
12995 Snow Road
Parma, Ohio 44130
Telephone: 216-267-2210
TWX: 810-421-8845

Eastern Area Parts
85 Harristown Road
Glen Rock, New Jersey 07452
Telephones: 201-447-4000
TWX: 710-988-5602

Pacific Southwestern Area Parts
P.O. Box 85036
San Diego, California 92138
Telephone: 714-578-2222
TWX: 910-335-1634

Gulf States Area Parts
8550 Katy Freeway, Suite 128
Houston, Texas 77024
Telephone: 713-932-8955

Southwestern Area Parts
P.O. Box 34290
3320 Belt Line Road
Dallas, Texas 75234
Telephone: 214-241-2151
TWX: 910-860-5505

Southeastern Area Parts
P.O. Box 368
Decatur, Georgia 30031
Telephone: 504-981-9800
TWX: 810-766-0876

5.1.2 Canadian Orders

Motorola Ltd.
National Parts Department
3125 Steeles Avenue
E. Willowdale, Ontario M2H 2H6
Telephone: 416-499-1441
TWX: 610-492-2713
Telex: 065-25191

5.1.3 All Other Countries

Motorola Inc., or
Motorola Americas, Inc.
International Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
U.S.A.
Telephone: 312-576-6492
TWX: 910-693-0869
Telex: 722443 or 722424
Cable: MOTOL PARTS

5.2 FACTORY PARTS CENTER

5.2.1 Mail Orders

Motorola, Inc.
Component Products Sales and Service
P.O. Box 66191
O'Hare International Airport
Chicago, Illinois 60666

5.2.2 Other Correspondence

Motorola, Inc.
Component Products Sales and Service
2553 N. Edgington Street
Franklin Park, Illinois 60131

5.3 GENERAL OFFICES

Motorola Communications and Electronics Inc.
Communications Group Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-3900

KIT BREAKDOWNS

FLN1450A Analog Input Module (AI-6)

- FLN4345A Main Board
- FLN5720A Hardware Kit
- FLN4436A EPROM Kit
- FLN4347A Housing

PERFORMANCE SPECIFICATIONS

GENERAL

Operating Voltage	11-15 Vdc
Input Current	9mA average (25° ambient) 65mA peak during computation
Input Protection	
Maximum Input Surge	2.5kV (IEEE Standard)
Maximum Normal Mode Input for Current Input (without damage)	±5V dc or ±3.5V rms
Maximum Normal Mode Input for Voltage Input (without damage)	±40V dc or 28V rms
Maximum Common Mode Input (without damage)	±28V dc or 20V rms
Operating Temperature	-30°C to +60°C
Relative Humidity	0-90% without condensation
Dimensions	1.6"x 8.3"x 3.7" (h x w x d)
Housing	Thermo-plastic modules

ANALOG

Resolution	9 bits + polarity
Digital Code	Two's complement
Linearity	±0.1% FS (±1/2 LSB)
Temperature Coefficient	100 PPM/°C
Analog Input Ranges	±1V; 4-20mA (standard)
Analog to Digital Conversion Time	70ms maximum @ 60Hz
Sampling Interval Per Channel	210 to 560ms @ 60Hz
Common Mode Rejection	60 dB
Maximum Common Mode Input for Linear Operation	2.5V rms or ±4V dc
Number of Analog Input Channels per Module	6
Local Display	Via the test connector on the Encoder module

PARAMETERS	
Change of Analog Value Detection (Per Input)	COS initiated by analog input module if the change of an analog value exceeds the previous reading by a predetermined percentage: 0 (continuous TX), 1, 2, 5, 10, 25, 40, infinity (no COS)
Analog Input Type	Voltage or current (live zero)
Input (Group) Usage (Data to be transmitted to the Encoder Module)	1. Actual input value 2. Derivative of the input value 3. Integral of the input value 4. Mask (input not used)
Number of Predetermined Sets of Parameters	15
Number of Predetermined Sets of Delta Values	7
Number of User Defined Sets of Parameters	5
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SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.

2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.

3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.

5. Use only a grounded soldering iron.

6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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GENERAL DESCRIPTION

1. GENERAL

The Analog Input Module (AI-6) is an expansion unit, which is configured with the Modular Remote Unit (MRU). The AI-6 monitors a maximum of six analog inputs and requests that the MRU transmit information to the central station when certain parameter-determined conditions exist. The AI-6 is housed in its own molded plastic unit and may be directly connected to the MRU unit via the bus connector.

The Encoder Module of the MRU is responsible for the communication of messages to the central station. The MRU supplies power to the AI-6 module and also ensures uninterrupted operation during ac power failure.

2. ANALOG INPUTS

The AI-6 is based on a microcomputer and contains six surge-protected analog inputs, which may be defined in any combination of the following two ranges: ±1 V and 4-20 mA.

3. PROCESSING

The analog measurements of the inputs are converted to digital data by the analog-to-digital converter and the microprocessor performs the necessary scaling and offsetting adjustments of the data. Computations performed depend on the data type which is associated with each input channel. The three data types that exist are:

a. Raw Data
b. Integral Data
c. Derivative Data

4. PARAMETERS

User-selectable parameters determine which of the three types of data corresponds to a given input channel and thus define the particular data computations required. Additional parameters referred to as "delta limits" determine when the status of the inputs should be transmitted to the central station. For transmission to occur, the AI-6 transforms the manipulated analog input measurement data into digital format according to the MRU AI-6 Encoder protocol and initiates a request to the Encoder to transmit the data. Certain parameters defined in the Encoder determine transmission characteristics such as PTT warmup time, FCC 2-second transmission limit, etc. Refer to the 68P02933G20 MRU Encoder Instruction Manual, for details.

An EPROM Programmer is available as an accessory to allow user-programming of parameters directly into the AI-6 microcomputer memory. The AI-6 Utility Program (FLN1465A) is an accessory, which simplifies entry of user-defined parameters.

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7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

WARNING

If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.

5. AI-6 - MRU BUS COMMUNICATIONS

Communication between the two modules occurs on a bus, which consists of six signal lines. Activity on the bus is controlled by the Encoder for the two existing modes of operation:

1. Communication between the AI-6 and the MRU Encoder may take place when the AI-6 has determined, via its inputs, that a message is to be transmitted to the central station. The AI-6 generates a signal on the bus, which the MRU Encoder recognizes as a request for transmission. The AI-6 waits to be recognized by the Encoder and only then are the codewords transferred. Once the Encoder receives all the necessary data, it enters into a transmission mode which is independent of any of the activities of the AI-6.

2. Communication between the AI-6 and MRU Encoder may also take place when the Encoder requests for a reporting of the status of analog inputs. This type of communication is completely initiated by the Encoder and occurs when one of the following conditions exists:

   a. The time counted by the periodic timer has elapsed (generated by the Encoder); or

   b. A test is activated from the Encoder.

   Refer to the 68P02933G20 MRU Encoder Instruction Manual for a detailed description of these features.

FUNCTIONAL DESCRIPTION

1. ANALOG INPUT MONITORING

Under microcomputer control, the AI-6 periodically (see Table 1) reads the measurements of each of the six analog inputs, performs calculations and compares the current value to the last transmitted value of an input. The specific calculations performed depend on whether the user has defined an input to be Raw, Integral or Derivative. If the rate of change between current and previous values is greater than a certain predefined limit (referred to as "delta limit"), the AI-6 will initiate a request to the Encoder to transmit a message to the central station.

Table 1.

Time Interval For One Input To Be Sensed

Number of inputs used	50 Hz	60 Hz
1	246	204.9
2	328	273.2
3	410	341.5
4	492	409.8
5	574	478.1
6	656	546.4

The analog measurement data is updated at intervals corresponding to the analog-to-digital converter cycle time and the number of analog inputs used.

The converter cycle time depends upon the ac line frequency and is 82 or 68.3 ms for 50 or 60 Hz respectively. The time interval for one input to be sensed is calculated by multiplying the number of inputs used plus two, by the converter cycle time (82 or 68.3 ms). The two additional inputs are internal measurements of the one-volt reference voltage and the ground voltage and are used for obtaining scaling and offsetting constants. These constants are used to cancel the influence of the reference voltage changes and of the input resistors tolerance on the A-D converter output.

2. RAW DATA

The measurement data read from the analog input is processed by an analog-to-digital converter. The digital values output from the A-D converter represent the "raw data," if no further computations are made to it. The raw data is parameter-selected and is represented in the INTRAC 2000 code word as a ten-bit two's-complement digital word whose range lies between -512 and +511 (decimal). Of this range, -500 corresponds to -1 V or 4mA, depending upon the input resistors and parameter-selected analog input range, and +500 similarly corresponds to +1 V or 20 mA. The values below -500 and above +500 allow 1% (of the full scale) overhead for transducer tolerance, and data values of -512 and +511 represent underflow and overflow analog values, respectively.

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Table 2. Raw Data Representation

Analog Input Measurement ±1 V	4-20 mA	Interpretation	Raw Data Representation
>1.02	>20.2	Overflow	+511
<1.02 >1.0	<20.2 >20.0	Max. allowable value	+501 to +510
1.000	20.00	Full scale (plus)	+500
<1.0 >0	<20.0 >12.0		+001 to +499
0 or open	12.00		+000
<0 >-1.0	<12.0 >4.0		-001 to -499
-1.000	4.00	Full scale (minus)	-500
<-1.0 >-1.02	<4.0 >3.84	Min. allowable value	-501 to -511
<-1.02	<3.84 or open	Underflow	-512

Note: For a detailed current or voltage conversion, refer to Appendix II or III, respectively.

3. INTEGRAL DATA

When integral data is parameter-selected, the raw data output by the A-D converter is processed and added with the digital data obtained one **integrating-interval** earlier. The integral computation employs a standard solution (trapezoidal rule) which approximately calculates the integral. The integrating-interval is a constant which is determined by the ac line frequency and the number of inputs used. (See Table 1.)

3.1 INTEGRAL DATA REPRESENTATION

The minimum allowable value for an input (-1 V or 4 mA) is represented as zero, therefore no negative values for the integral can exist. The integral data is represented in the INTRAC 2000 code word as a ten-bit digital word whose range lies between 0 and 999.

The digital value held in the ten-bit register is the sum of all previous computations. When the value reaches 999, the maximum full scale is reached and the updated sum begins again from zero. In this event a request to transmit to the central station is initiated (except if the delta limit is assigned a value of "infinity"). In order to interpret the data properly, the central station must receive the data each time the maximum full scale is surpassed (1000 counts). Table 4 and Table 5 depict the time period in which the maximum full scale is reached for different input levels.

Underflow and overflow are both represented by the value 1023 and indicate that the analog input measurement data did not fall within the acceptable range (i.e. >1.02 V, <-1.02 V, >20.2 mA or <3.84 mA).

Table 3. Integral Data Representation

Data Interpretation	Data Representation
Overflow	1023
Maximum allowable value	999
Full scale (max)	999
Full scale (min)	0
Minimum allowable value	0
Underflow	1023

3.2 INTEGRAL ALGORITHM

The AI-6 calculates the sum of the current raw data and the previous raw data and divides by two. This quantity is added to the previous integral computed and thus the current integral value is obtained.

Computations are performed with 23-bit precision, of which the 10 most significant bits constitute the value prepared for transmission. Truncating the 13 least significant bits from the result is the equivalent to performing a division by 8,192 which becomes a constant by which the central station must multiply the digital data it receives, in order to obtain results in meaningful units of measure.

3.3 EXAMPLE FOR INTEGRAL

It is assumed in this example that the input has a constant 20 mA value in a 50 Hz system. Table 6 shows that the time between transmissions is a function of the delta limit assignment and is the number of counts divided by the Integrator Increment Rate (see Table 5).

Table 4. Integrator Timing
60 Hz System

% of Full Scale	Input Level ± 1 V	4-20 mA	Integrator Increment Rate (counts/sec)	Period to reach 1000 counts (minutes)
0	-1 V	4 mA	0	-
10	-.8	5.6	0.18	91.5
20	-.6	7.2	0.36	45.7
30	-.4	8.8	0.54	30.5
40	-.2	10.4	0.73	22.9
50	0	12	0.91	18.3
60	.2	13.6	1.09	15.2
70	.4	15.2	1.27	13.1
80	.6	16.8	1.46	11.4
90	.8	18.4	1.64	10.2
100	1	20	1.82	9.1

Table 5. Integrator Timing
50 Hz System

% of Full Scale	Input Level ± 1 V	Input Level 4-20 mA	Integrator Increment Rate (counts/sec)	Period to reach 1000 counts (min)
0	-1 V	4 mA	0	-
10	-.8	5.6	0.15	109.8
20	-.6	7.2	0.36	54.9
30	-.4	8.8	0.46	36.6
40	-.2	10.4	0.61	27.4
50	0	12	0.76	21.9
60	.2	13.6	0.91	18.3
70	.4	15.2	1.06	15.7
80	.6	16.8	1.21	13.7
90	.8	18.4	1.37	12.2
100	1	20	1.52	11.0

NOTE

For voltage integral measurements, an analog input of 0 V (or no connection to the input) will cause the integral output to accumulate and reach 1000 counts after approximately 18 minutes for 60 or 50 Hz respectively.

Table 6. Example for Integral

Delta Limit (%)	Number of counts	Time between transmissions	Time to reach 1000 counts
10	100	67 sec. (100/1.52)	11 minutes
25	250	168 sec. (250/1.52)	11 minutes

4. DERIVATIVE DATA

When derivative data is parameter-selected, the raw data output by the A-D converter is subtracted from the raw data computed one **differentiating interval** earlier; this difference is stored along with the eight differences computed during the eight preceding differentiating intervals. The differentiating interval depends upon the ac power line frequency, and is 16.892 seconds if the ac line frequency is 50 Hz and 14.070 seconds if the ac line frequency is 60 Hz. Very small digital differences are averaged with previous differences to prevent small changes from appearing as large precentage values. If the digital difference is relatively large, then it is averaged with the previous difference to damp any sudden peaks that may occur, since the high difference may have been due to spurious noise or other interference.

4.1 DERIVATIVE DATA REPRESENTATION

The derivative data is represented in the INTRAC 2000 codeword as a ten-bit two's complement digital word whose range lies between -512 and +511. Of this range, +500 represents the positive full scale and -500 represents the negative full scale. Underflow or overflow occurs when either the calculated derivative is under or over the allowable values or when the analog input measurement data does not have acceptable values (i.e. >1.02 V, <-1.02 V, >20.2 mA or <3.84 mA). Underflow also occurs and is reported during initialization of the AI-6 module.

Table 7. Derivative Data Representation

Data Interpretation	Data Representation
Overflow	511
Maximum allowable value	510
Full Scale (plus)	500
Full Scale (minus)	-500
Minimum allowable value	-511
Underflow	-512

If an underflow or overflow occurs, all computations are restarted and the first derivative after the underflow/overflow condition is zero. During the next five differentiating intervals the derivatives are the differences themselves even if they exceed the value 100 or are less than 10 (see algorithm and example below).

4.2 DERIVATIVE ALGORITHM

Step 1: The AI-6 calculates the difference between the current raw data and the previous raw data. This difference is referred to as the "current difference" and is stored in a buffer along with eight previous differences.

Step 2: The AI-6 then computes the weighted average of differences. One-quarter of the current difference plus 3/4 of the weighted average calculated one differentiating interval earlier, constitutes the current **weighted average.**

Step 3: The AI-6 checks the value of the current difference which was calculated in step 1.

If the current difference falls within the range of 10 and 100 then the difference is not too small or too large and the derivative is simply the computed difference.

If the current difference is greater than 100 then the weighted average which was calculated in step 2 becomes the derivative prepared for transmission.

If the current difference is less than 10 then an additional series of calculations is made:

> The AI-6 adds the current difference to the previous difference in order to obtain a sum. If that sum is less than 10, the AI-6 adds the next previous difference to the sum. If the new sum is still less than 10, the AI-6 continues to add the previous differences either until the sum equals or exceeds 10, or until eight previous differences have been added to the current difference.
>
> Case 1: If adding eight previous differences does not produce a sum equal to or greater than 10, the change is considered very small and the AI-6 assigns the value of zero to the derivative of the current difference.
>
> Case 2: If the AI-6 reaches a sum equal to or greater than 10, and that sum is smaller than 127, the AI-6 divides that sum by the number of differences added together to achieve that sum. The resulting quotient is the derivative of the current difference.
>
> Case 3: If the AI-6 reaches a sum greater than 127, the AI-6 divides 127 by the number of differences added together to achieve that sum. The resulting quotient is the derivative of the current difference.

4.3 EXAMPLE OF DERIVATIVE

Table 8. Example of Derivative

Input current (mA)	Current raw value	Difference	Sums of differences	Average	Value taken as derivative	Condition
0	-512	-	-	0	-512	underflow
6.53	-342	-	-	0	0	1st deriv=0
10.94	- 66	276	-	69	276	
10.94	- 66	0	-	51	0	derivative
14.67	168	234	-	96	234	=
6.69	-332	-500	-	-53	-500	difference
9.78	-139	-193	-	8	-193	
12.56	35	174	-	49	49	difference
15.73	233	198	-	85	85	> 100
16.64	290	57	-	-	57	difference
17.71	357	67	-	-	67	>10 & <100
17.81	363	6	73	-	36	
17.78	361	-2	71	-	24	
17.89	368	7	11	-	3	difference
17.81	363	-5	73	-	14	<10
17.81	363	0	73	-	12	
17.81	363	0	73	-	10	
17.81	363	0	73	-	9	
17.81	363	0	73	-	0	

- signifies that the data is irrelevant.

NOTE

If the difference is less than ten and the change is slow, namely, if any change occurs after more than 2 minutes (e.g. 8 differentiating intervals have elapsed the derivative value is always zero.

5. DELTA LIMITS

The AI-6 initiates a request to the Encoder for transmission when any raw, integral or derivative value differs from the value previously transmitted to the central station, by a predefined percentage. The percentage value is referred to as a "delta limit" assignment and is parameter-determined to have a value of either 0%, 1%, 2%, 5%, 10%, 25%, 40% or "infinity." The delta limit selected for an analog limit represents a percentage of the full scale. Since the full scale range is always 1000 counts, each percentage point constitutes ten counts. A delta limit assignment of zero represents continuous transmissions. This assignment is not intended for regular use and is reserved for test purposes only. A delta limit assignment of "infinity" never causes transmissions to the central station. In this case the analog information is transmitted to the central station only upon a periodic timer or a test transmission.

Table 9. Counts per Delta Limit Assignment

	DELTA LIMIT ASSIGNMENT							
Data Type	0%	1%	2%	5%	10%	25%	40%	infinity
Raw	cont. tx	10	20	50	100	250	400	no tx
Integral	cont. tx	10	20	50	100	250	400	no tx
Derivative	cont. tx	10	20	50	100	-	-	no tx

6. INITIALIZATION

The AI-6 module begins the initialization process if a negative-going pulse is sensed at the RESET input of the microprocessor. This may occur either if the power is initially supplied or the watchdog timer is activated due to program run-away.

During initialization, all previously stored data used for integral and derivative computations are lost and the process is started from the beginning. The program performs initialization of the ports and of the timer, clears the internal and external RAM, reads the parameter switches and updates the parameters accordingly. In addition, the AI-6 initiates a request to the Encoder for transmission of an underflow condition (-512 for raw and derivative; 1023 for integral) for all the existing groups whose delta limit assignment is not "infinity."

The transmission of the underflow condition is intended to inform the central station that a restart occurred in the AI-6 module and signifies that the integral and derivative calculations have been started again. To allow the voltages to stabilize after power-up, the transmission of underflow occurs after a delay of approximately two seconds after the RESTART pulse is sensed. Immediately after this transmission, the data existing at the inputs is measured and is transmitted if its value falls within the allowable range and the corresponding delta limit assignment is not "infinity."

Two seconds after power-up or the watchdog timer is activated, three transmissions are performed if the delta limit assignment is not "infinity":

Transmission 1: Group C - Underflow
Transmission 2: Group C - Updated; Groups D-H - Underflow
Transmission 3: Groups D-H - Updated

7. UNDERFLOW/OVERFLOW

Underflow or overflow data is represented for each of the input data types as follows:

	Raw	Derivative	Integral
Underflow	-512	-512	1023
Overflow	511	511	1023

The effects of an underflow or overflow (UF/OF) condition are summarized below:

a. If UF/OF occurs because of initialization, then the previous integral and derivative calculations are lost.

b. If UF/OF occurs because the input value is out of range, the integral summation is stopped until the input value is within range and only then is the summation resumed. The derivative is lost in this case and all calculations are started from the beginning.

c. Immediately after the condition which caused the UF/OF disappears, the data (raw and integral only) associated with the affected group(s) are transmitted, provided that the delta limit assignment is not "infinity."

d. If the UF/OF condition exists for more than one cycle, the UF/OF is transmitted only once. If, however, UF and OF are alternating, then the corresponding value (OF or UF) is transmitted each time.

Table 10. Causes of Underflow or Overflow

Condition of Occurrence	Data	Group Affected
Two seconds after initialization	UF	all groups
Voltage input <-1.02V for group x	UF	group x
Current input <3.84mA for group x	UF	group x
Voltage input >1.02V for group x	OF	group x
Current input >20.16mA for group x	OF	group x
Group x designated as derivative and input voltage decrease is >1.02V	UF	group x
Group x designated as derivative and input current decrease is >8.16mA	UF	group x
Group x designated as derivative and input voltage increase is >1.02V	OF	group x
Group x designated as derivative and input current increase is >8.16mA	OF	group x
Ground reading at the A/D input less than 1.03V or greater than 1.29V	UF	all groups
1-volt reading at the A/D input less than 1.96V or greater than 2.36V	OF	all groups

8. CENTRAL STATION CONSTANTS

In order for the central station to interpret properly the AI-6 data received from the MRU, a set of constants is required. These constant figures are used to transform the received data into meaningful units of measure. Table 11, displays the constant factors required for raw, integral and derivative input data types for a 50 or 60 Hz system.

Table 11. Central Station Constants

Input Data Type	Mains Frequency 50 Hz	 60 Hz
RAW	1	1
INTEGRAL (units/sec)	671.74	559.8
INTEGRAL (units/min)	11.196	9.33
INTEGRAL (units/hr)	0.187	0.156
DERIVATIVE (units x sec)	16.892	14.076
DERIVATIVE (units x min)	0.282	0.235
DERIVATIVE (units x hr)	0.00469	0.00391

To calculate the real value of the data received at the central station, the following formulas are used:

Integral: $Y = K_i F V$

Derivative: $Y = 1/K_d F V$

where:

V is the INTRAC 2000 transmitted value.

F is the central factor which translates counts to units which are defined at the central station.

$$F = \frac{\text{central range}}{\text{remote range}} = \frac{\text{maximum - minimum customer units}}{1000}$$

K_i, K_d are the central station constants as given in Table 11.

Y is the data transformed into meaningful units.

9. ENCODER - AI-6 COMMUNICATIONS PROTOCOL

The MRU Encoder module constantly monitors the status of the AI-6 module via the bus interface and transmits to the central station after there has been activity on the bus.

9.1 SIGNAL LINES

The bus consists of six signal lines:

CK	Clock; generated by the Encoder only.
ADDR	Address; clocked serially by the Encoder.
DATA	Data transfer from AI-6 module to Encoder.
BREQ	Bus Request; generated by AI-6 and indicates a request to send.
BUSY	Busy; indicates bus is busy; generated by the Encoder
READY	Ready; indicates existence of AI-6, also used to feed-back the CK signal for handshaking; generated by AI-6 module.

9.2 OPERATION

There are two modes of operation:

1. The Encoder interrogates the AI-6 because:

   a. The time counted by the periodic timer has

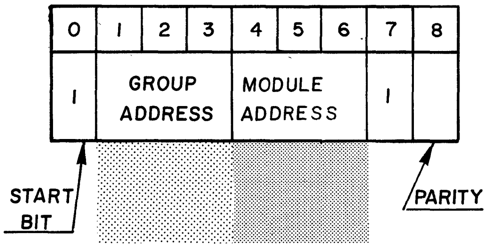


Figure 1. Encoder-AI-6-Message Format

elapsed. (The Periodic Timer is parameter defined in the Encoder and causes a transmission to the central station when the predefined time interval has elapsed.)

2. The AI-6 requests transmission because a "delta" limit was exceeded.

9.3 COMMUNICATION PROCEDURE

The AI-6 may initiate the communication procedure by setting BREQ line low. When the Encoder senses this or wishes to initiate communications, the procedure begins.

a. Encoder pulls BUSY line low, indicating start of communication.
b. Encoder sends module's address on ADDR line by clocking it serially using CK line as clock. ADDR is active low.

AI-6's address consists of 9 bits (Refer to Figure 1).

Bit 0	Start bit; always "1"
Bits 1-3	Indicate the group (C-H)
Bits 4-6	Indicate the module address
Bit 7	Indicates data flow direction: "1" for AI-6 to Encoder; "0" for Encoder to AI-6
Bit 8	Parity bit (odd)

b. A **test** is activated by pressing the Test (PTT) button on the MRU Encoder or by pressing the self test button on the MRU Decoder. (When the test is being performed, the MRU reports the condition of all inputs, to the central station.)

c. If the addressed AI-6 module exists, it starts to echo the CK signal on the READY line.

d. The Encoder sends clock pulses on the CK line. These pulses clock the data from the AI-6 module (data is active low logic). To ensure fast and reliable data transfer, the Encoder monitors the READY line for clock transitions.

Data is transferred from the AI-6 to the Encoder via the DATA line and consists of a message 20-bits long.

Bit 0:	"0" indicates that no change of state (exceeding of delta limit) occurred in the addressed AI-6; "1" indicates that a change of state occurred in the addressed AI-6.
Bits 1-3	Group address bits, for groups C-H.
Bits 4-6	Module address bits (0-3) see note.
Bits 7-8	"0 1" indicate that the message is 10-bits long.
Bits 9-18	Data bits
Bit 19	Parity bit (odd)

e. Upon completion of data transfer, the ENCODER releases the BUSY line.

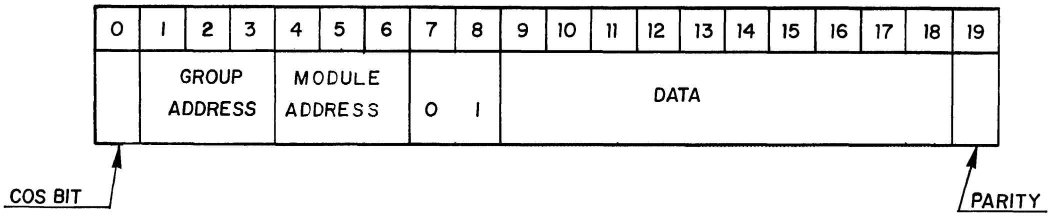


Figure 2. AI-6 - Encoder Message Format

The Encoder communicates with all groups of the AI-6 (C-H) whose input changes satisfy the conditions for transmission to the central station. If more than one group requires transmission, the Encoder recognizes each group in order C-H. When the Encoder has completed communications with the AI-6 at group H, a transmission to the central station is initiated. (Refer to the 68P02933G20 Encoder Instruction Manual for details concerning the "transmission mode.")

NOTE

The AI-6 module address is determined by two DIP switches, the only allowable module address is 000: S1-8 or S3-1, S1-9 or S3-2 set to "0".

10. ENCODER - CENTRAL STATION COMMUNICATIONS

The Encoder transmits information consistent with the INTRAC 2000 protocol by means of a pulse duration-encoded binary word containing 32 bits. The code words are expressed as frequency-shift keying (FSK) tones which frequency modulate (FM) the RF carrier.

10.1 MESSAGE BURSTS

The MRU communicates by means of transmission bursts. All groups whose values indicate that a transmission is required have their corresponding code words concatenated and separated by frame syncs. A single message burst consists of four repetitions of this string of code words. If, for example, all six groups (C-H) require transmission, a message burst would consist of 24 code words. If the FCC LIMIT parameter is set at the Encoder, then a two-second time limit is imposed on transmission time and, if necessary, only a portion of the burst is transmitted.

If, during transmission, analog inputs are varying and require communication with the Encoder, they are recognized by the AI-6 during the "transmission interval" and reported in the next transmission burst. If an input varies enough, during a single message burst, to require more than one transmission, only the first value will be reported.

10.2 CODE WORD FORMAT (FIGURE 3.)

a. Bit 0 is always logic 1.

b. Bits 1-9 form the address code of the particular MRU encoder module and is initially factory-assigned.

c. Bits 10-11 form the system address

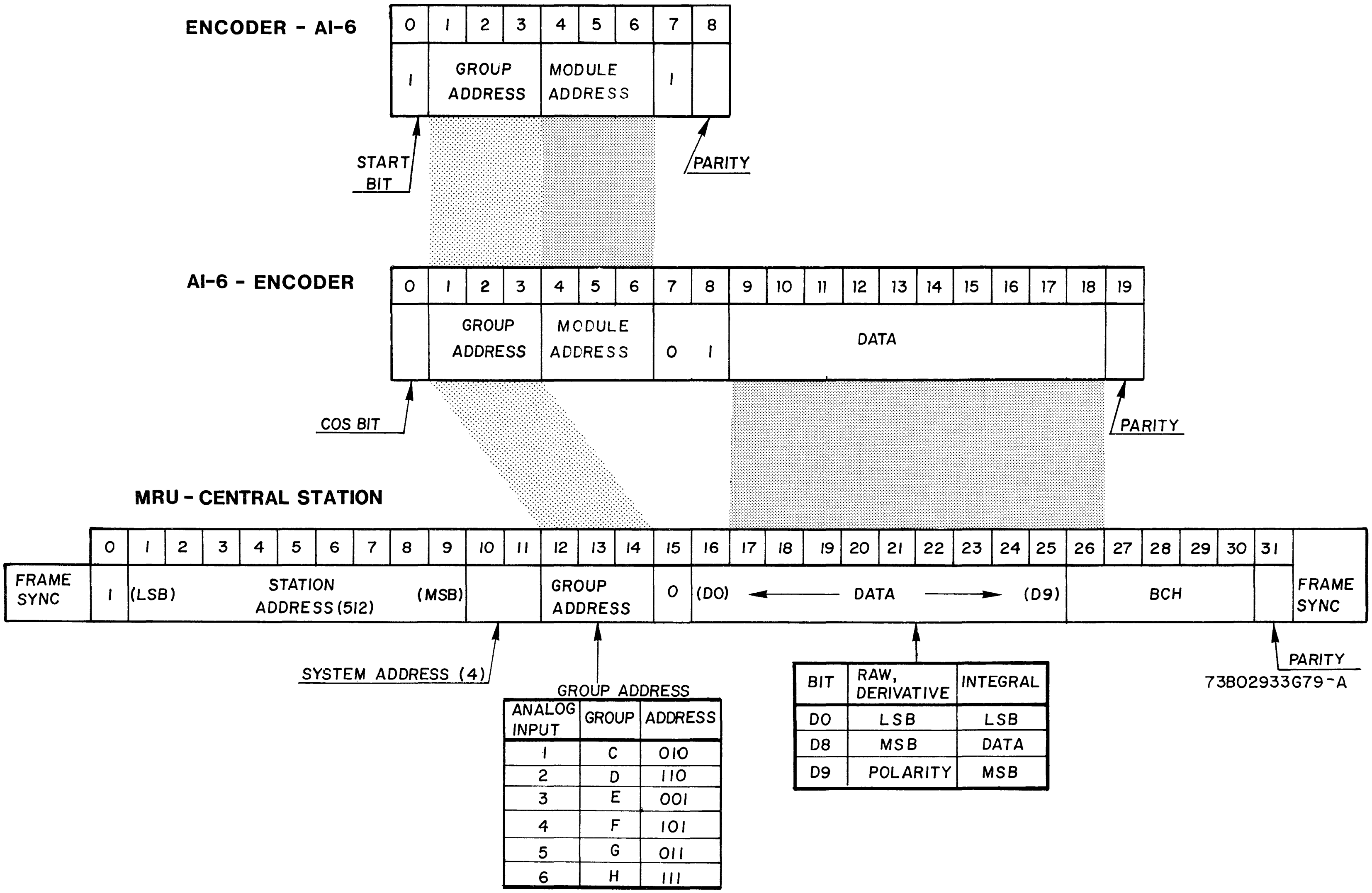
d. Bits 12-14 are used to define one of the six groups (C-H).

e. Bit 15 is always 0.

f. Bits 16-25 represent the value of the input as designated by the group code (bits 12-14). Refer to tables 2, 3, and 7, Data Representation column, for possible values.

g. Bits 26-30 constitute a Bose-Chaudhuri cyclic code, a function of all the preceding bits.

h. Bit 31 provides a parity check for the entire code word; it is logic 1 if the preceding 31 bits contain an even number of logic 1's.



GROUP ADDRESS

ANALOG INPUT	GROUP	ADDRESS
1	C	010
2	D	110
3	E	001
4	F	101
5	G	011
6	H	111

BIT	RAW, DERIVATIVE	INTEGRAL
D0	LSB	LSB
D8	MSB	DATA
D9	POLARITY	MSB

Figure 3. Code Word Format (MRU - Central Station)

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INSTALLATION

1. PRELIMINARY

Carefully inspect the AI-6 module immediately upon receipt and notify the shipper of any damage incurred in transit. The installation procedure consists of mounting the housing, making the necessary external and internal electrical connections, and determining the initial operating conditions of the MRU.

2. MOUNTING

Mount the AI-6 module next to the other MRU modules with the two captive screws (included with the module) then connect the MRU bus cable to the bus connector of the AI-6.

3. DISASSEMBLY

To either access jumpers, switches, or to program the EPROM, the AI-6 must be disassembled. Follow the directions below for proper disassembly of the AI-6 housing (refer to Figure 2).

Step 1. Disconnect the MRU bus cable.

Step 2. Loosen the two captive screws which hold the module to the mounting plate.

Step 3. Loosen the two screws on the right panel of the AI-6 housing.

Step 4. Lift the latch door located at the top of the housing, if it is closed.

Step 5. Gently separate the two sides, the PC board is now exposed.

4. JUMPERS

Refer to Figure 3. Printed Circuit Board.

Changing jumper settings involves delicate work on the PC board. This operation is best performed first before any connections are made to the AI-6 module.

WARNING

> Touch the metal coating inside the housing before changing any jumper setting, to dissipate any static charge that might otherwise damage the CMOS integrated circuits.

The factory supplies the AI-6 module with all the jumpers predetermined by means of foil printed on the lower (foil) side of the printed circuit board. These connections determine the normal (by default) operation of the AI-6. To change a connection, carefully cut the foil. Then solder a short piece of bare wire between the holes in the printed circuit board.

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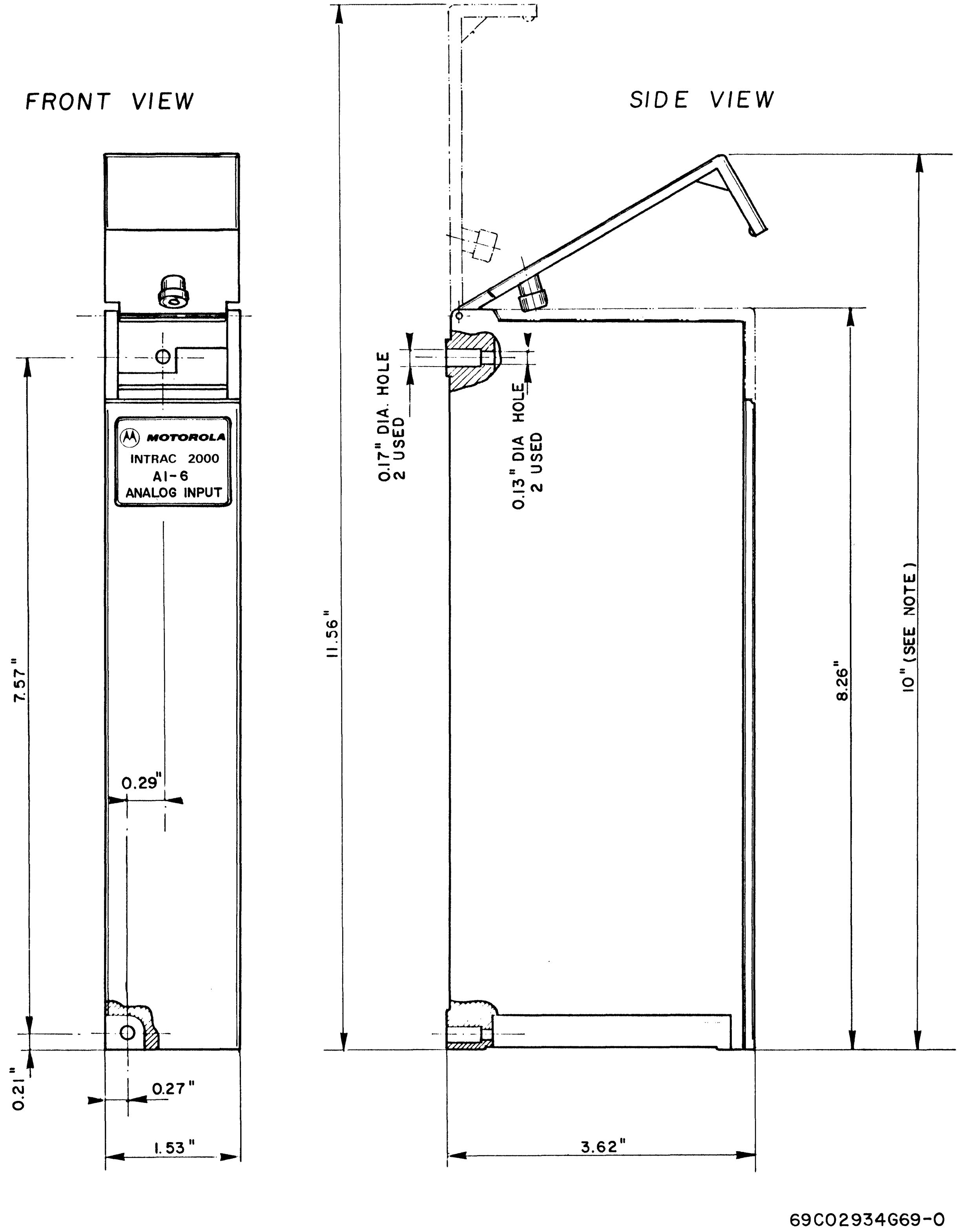

NOTE

MINIMUM OPENING FOR REMOVING WIRE CONNECTOR.

Figure 1. Housing Detail

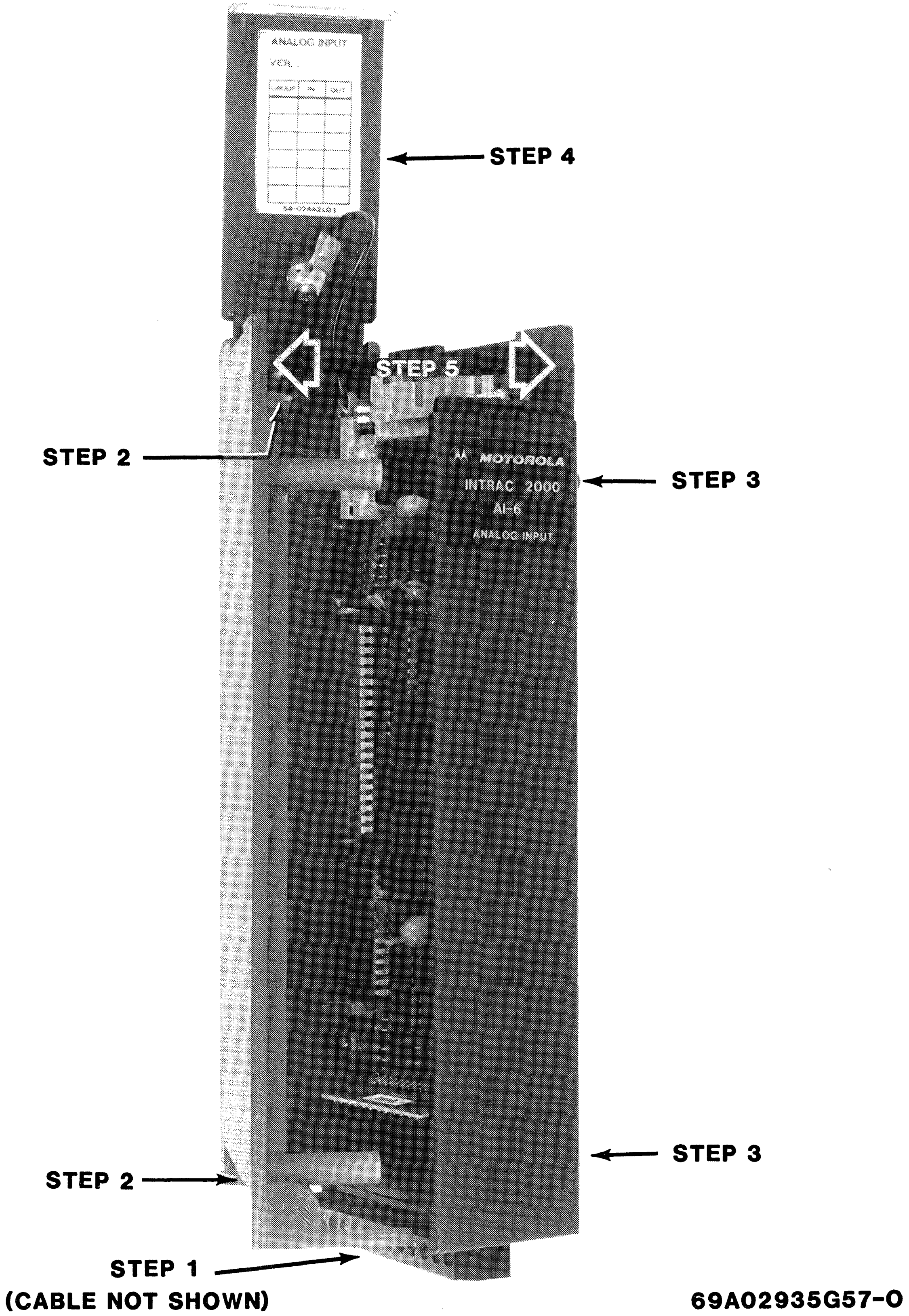

Figure 2. Disassembly

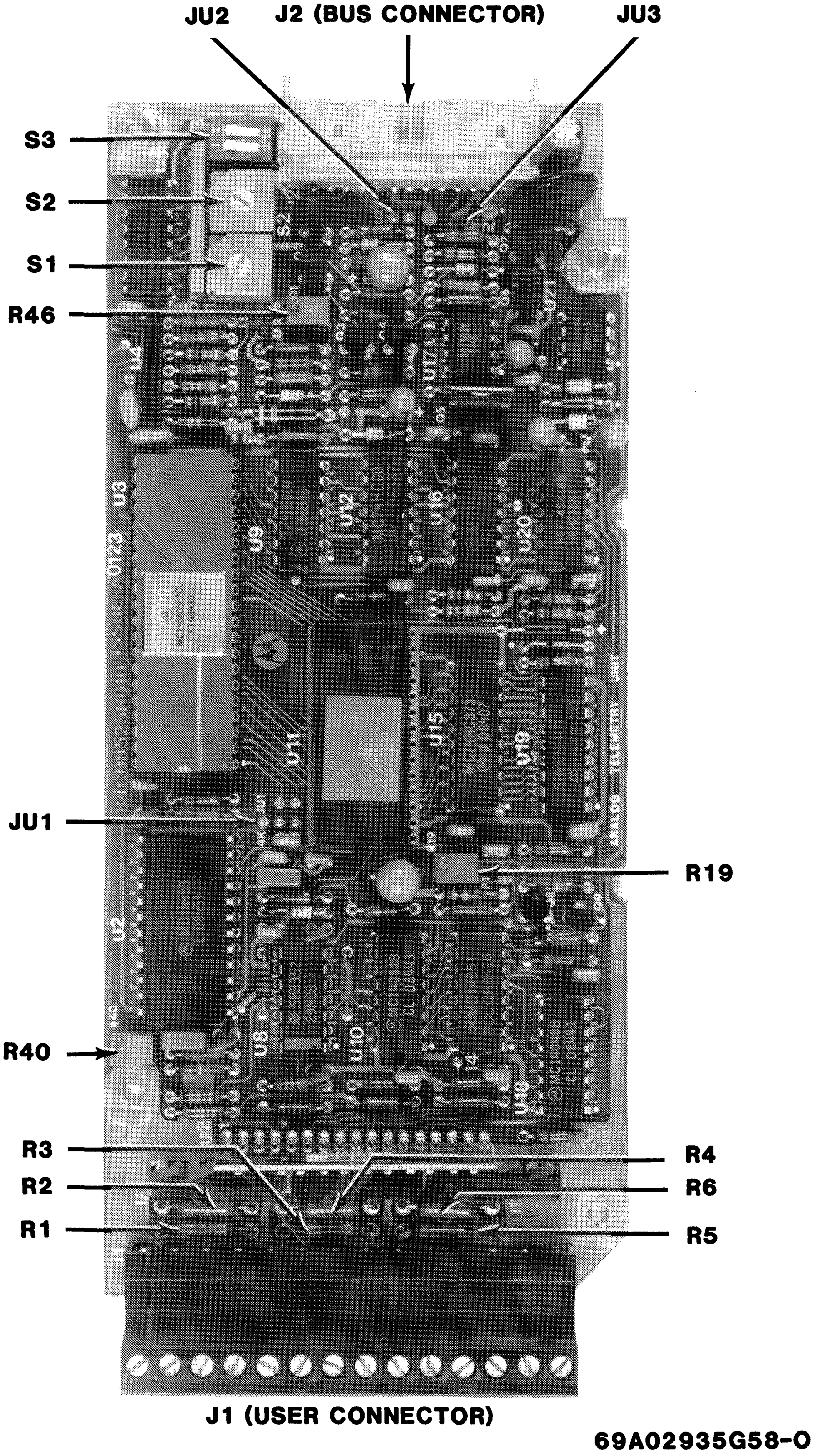

Figure 3. Printed Circuit Board

Table 1. AI-6 Jumper Settings

Jumper	Default Setting	Function	Optional Setting	Function
JU1	Connected 8K	Selects 8K EPROM	Connected 2K	Connects 2K EPROM
JU2	Disconnected	AI-6 continues operation during power failure	connected	During power failure, back-up power is disconnected from the AI-6
JU3	Connected		disconnected	

CAUTION

Do not attempt to change the settings of jumpers intended for factory use only.

5. SWITCHES

The switches in the AI-6 module are used to:

a. Select one of the preprogrammed Input/Output parameter sets;

b. Select one of the preprogrammed Delta Limit parameters sets; and

c. Select the AI-6 module address.

The AI-6 is available in two configurations; one includes a single 9-station DIP switch and another includes two rotary switches and a 2-station DIP switch. Refer to Table 2, for the correspondence between the switches and their functions.

NOTE

The module address DIP Switch S3 (or S1-8 to S1-9) is factory set for address zero.

6. EXTERNAL CONNECTIONS

6.1 GENERAL

All electrical cables should be consistent with the mounting location environment and should conform to applicable electrical codes.

Use weatherproof cable entrance hardware and proper external housing for outdoor installations.

For approved fire and security installations, refer to applicable regulations such as NFPA72D or other local requirements.

6.2 BUS CONNECTION

The connection between the AI-6 and MRU Encoder is done via a 26 pin flat cable connected to the Bus Connector J2 on the AI-6. In order to insert the cable connector correctly to J2, the user must match the triangular sign on the male and female connectors (the triangular sign on the cable connector is on the same side as the red-painted wire on the cable). There are also connectors with a key profile, in which case no mistake can be made.

Table 2. Switch Configurations

Configuration 1	Configuration 2			Function
9-Station DIP Switch S1	Rotary Switches		2-Station DIP Switch S3	
	16 Pos S1	10 Pos S2		
S1-1 to S1-4 (LSB)	O-F	-	-	Selects I/O Parameter Set. (See table 6)
S1-5 to S1-7 (LSB)	-	0-7	-	Selects Delta Limit Parameter Set. (See table 7)
S1-8 to S1-9 (LSB)	-	-	S3-1 to S3-2	Select Module address (0 to 3)

6.3 ANALOG INPUT CONNECTION

The AI-6 analog inputs are differential and floating, designed to reject common-mode noise (voltages common to both sides of the input). Nevertheless, precautions should be taken to minimize common-mode noise, because (1) imbalance anywhere in the input circuit, including the source, converts common-mode signals to normal-mode signals, and (2) the AI-6 analog inputs do not reject common-mode signals exceeding 2.5V ac rms or ± 4.5 V dc. Either imbalance or too large a common-mode voltage will render the analog readings incorrect.

To minimize common-mode noise pickup, twisted-pair shielded cable are recommended for analog signals. The shield of the cable should be connected only to the AI-6 ground. If, however, the source is not grounded elsewhere, the shield may also be connected to the source to serve as its ground. Both terminals of the analog transducer should be floating with respect to ground; but if the transducer is single-ended, having one side grounded at the source, it should be treated as differential by connecting the low side of the cable pair to the transducer ground. In this case, the cable shield should connect only to the input board ground terminal. Figure 4, Analog Input Wiring, illustrates various methods of effecting connections to the analog inputs. Note that single-ended transducers having one lead connected to the source, are not recommended; they impair the differential input balance, preventing the AI-6 from rejecting common-mode noise.

6.3.1 Voltage or Current Selection

The factory produces the AI-6 board so that it is preset for current input (4-20 mA) usage and resistors R1 to R6 are rated 62.6 Ohms, ±0.1%.

When the user wishes to select a voltage input (±1V), the corresponding resistors must be replaced with resistors which are rated 10 kohms, ±5% (resistor R1 corresponds to input 1, R2 to Input 2, etc.).

Table 3. Analog Input Connections
(for Analog Input Wiring, see Figure 4)

User Connector TB1 (connected to J1 on PCB)	Polarity	Analog Input	Analog Group	Resistor
1 2	+ -	1	C	R1
3 4	+ -	2	D	R2
5 6	+ -	3	E	R3
7 8	+ -	4	F	R4
9 10	+ -	5	G	R5
11 12	+ -	6	H	R6
13		NOT USED		
14		GROUND		

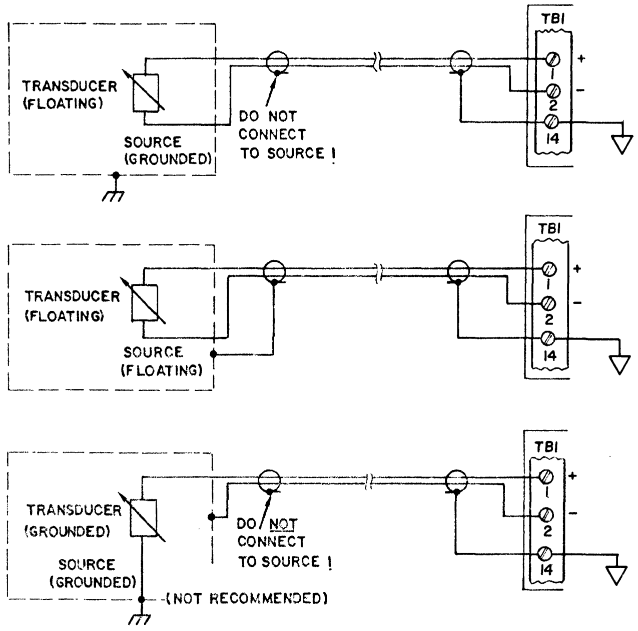

Figure 4. Analog Input Wiring

Table 4. Preprogrammed Combinations of the Input/Output Parameter Sets

Parameter Set #	Analog Inputs					
	1	2	3	4	5	6
0	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA
1	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Integral 4-20 mA	Integral 4-20 mA
2	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Deriv 4-20 mA	Deriv 4-20 mA
3	Raw ±1V	Raw ±1V	Raw ±1V	Raw ±1V	Raw ±1V	Raw ±1V
4	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw ±1V	Raw ±1V
5	Raw 4-20 mA	Deriv 4-20 mA	Integral 4-20 mA	Raw ±1V	Deriv ±1V	Integral ±1V
6	Masked	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Integral 4-20 mA
7	Masked	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Deriv 4-20 mA
8	Masked	Masked	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA
9	Masked	Masked	Masked	Raw 4-20 mA	Raw 4-20 mA	Raw 4-20 mA
10	Masked	Masked	Masked	Masked	Raw 4-20 mA	Raw 4-20 mA
11	Masked	Masked	Masked	Masked	Raw 4-20 mA	Integral 4-20 mA
12	Masked	Masked	Masked	Masked	Raw 4-20 mA	Deriv 4-20 mA
13	Masked	Masked	Masked	Masked	Masked	Raw ±1V
14	Masked	Masked	Masked	Masked	Masked	Raw 4-20 mA
15	User-programmable combination (EPROM programmer required)					

Note: See the Switches paragraph in this section for switch settings for each parameter set.

Groups of masked analog inputs may be used for status inputs.

7. PARAMETERS

The AI-6 has two parameter sets which are initially factory-set. The **Input/Output Parameter Set** defines the characteristics of each of the six analog inputs such as type of input measurement data (voltage or current) and type of output data (raw, integral or derivative). The **Delta Limit Parameter Set** defines when and if a change at any of the six inputs will generate a transmission to the central station. The user decides which parameters to assign each input, based on his specific requirements. Refer to the 68P02933G41 Functional Description section, of this manual for a detailed discussion of these parameters.

7.1 PREPROGRAMMED PARAMETER SETS

For the Input/Output parameter set, there are 15 preprogrammed combinations (Table 4) of which the user chooses one, via rotary switch S1 (or DIP switch S1-1 to S1-4).

For the Delta Limit Parameter Set, there are seven preprogrammed combinations of which the user chooses one via rotary switch S2(or DIP switch S1-5 to S1-7).

7.2 ACTIVATING A PREPROGRAMMED PARAMETER SET

To activate a predefined combination for each of the parameter etc, a rotary switch (or DIP switch, depending on the user's particular configuration) is set. See Table 6 for the settings for Input/Output Parameter Set selection and Table 7 for Delta Limits Parameter Set selection. (For DIP switch settings, "0"=open and "1"=closed.)

Table 5. Preprogrammed Combinations of the Delta Limit Parameter Sets

	Analog Inputs					
Parameter Set #	1	2	3	4	5	6
0	continuous	continuous	continuous	continuous	continuous	continuous
1	2%	1%	2%	1%	2%	1%
2	5%	2%	5%	2%	5%	2%
3	5%	5%	5%	5%	5%	5%
4	25%	10%	25%	10%	25%	10%
5	25%	10%	2%	25%	5%	2%
6	infinity	infinity	infinity	infinity	infinity	infinity
7	user-defined combination					

Note: See the Switches paragraph in this section for switch settings for parameter selection.

Table 6. Input/Output Parameter Set Selection

Parameter Set Selected	DIP Switch Setting S1-1	S1-2	S1-3	S1-4	Rotary Switch S1 Setting
0	0	0	0	0	0
1	1	0	0	0	1
2	0	1	0	0	2
3	1	1	0	0	3
4	0	0	1	0	4
5	1	0	1	0	5
6	0	1	1	0	6
7	1	1	1	0	7
8	0	0	0	1	8
9	1	0	0	1	9
10	0	1	0	1	A
11	1	1	0	1	B
12	0	0	1	1	C
13	1	0	1	1	D
14	0	1	1	1	E
15	1	1	1	1	F

Table 7. Delta Limit Parameter Set Selection

Parameter Set Selected	DIP Switch Setting S1-5	S1-6	S1-7	Rotary Switch S2 Setting
0	0	0	0	0
1	1	0	0	1
2	0	1	0	2
3	1	1	0	3
4	0	0	1	4
5	1	0	1	5
6	0	1	1	6
7	1	1	1	7

7.3 EPROM PROGRAMMING

If the user wishes to choose other than the predefined parameter sets, he must select a "user-defined combination" via the switches and enter his special values into the EPROM of the AI-6 module. This requires the use of an EPROM Programmer such as the Motorola FLN2317A EPROM Programmer with a recommended terminal. Because the EPROM is socket mounted, it can be modified at any time. To perform modification, first disconnect the MRU BUS cable which connects the MRU AI-6 and disassemble the housing as outlined in paragraph 3 of this section. Carefully remove the EPROM from its socket. When replacing the EPROM after programming is completed, care should be taken to insert it in the proper direction. The notched edge of the EPROM should always point in the direction of user connector J1.

Never attempt to change the CMOS EPROM to a normal NMOS EPROM.

Note that a Utility Program (FLN4364A or FLN4365A respectively) is available for convenient entry of parameters when using the FLN2317A EPROM Programmer in conjunction with the HP 86A/87A/87XM or an IBM PC computer.

NOTE

Paragraphs 7.4 to 7.8 need only be reviewed if the Analog Input Utility Program is used.

7.4 AI-6 PARAMETER DIRECTORY REGISTER

The EP"OM enables the user to program his own Input/Output Parameter Set and Delta Limit Parameter Set. The user can alter the Input/Output Parameter Set five times and the Delta Limit Parameter Set three times. Each user-defined parameter set occupies a different starting address in the EPROM memory.

The **AI-6 Parameter Directory Register** points to the currently active set. The register is 8-bits wide where bits 0-4 point to a respective Input/Output Parameter Set and bits 5-7 point to a respective Delta Limit Parameter Set. Therefore, when programming a new set of parameters, the user must update the AI-6 Parameter Directory Register as well.

Initially, bits 0-4 are all set to 1's. Note that for each alteration of the Input/Output Parameter set, the right-most "1" is each time set to zero.

Table 8. Parameter Directory Register
Input/Output User-defined Parameter Set

Address: FB5

User-defined	Bit Position				
Parameter Set #	4	3	2	1	0
1st	1	1	1	1	1
2nd	1	1	1	1	0
3rd	1	1	1	0	0
4th	1	1	0	0	0
5th	1	0	0	0	0

Table 9. Parameter Directory Register Delta Limits User-defined Parameter Set

Address: FB5

User-defined Parameter Set #	Bit Position 7	6	5
1st	1	1	1
2nd	0	1	1
3rd	0	0	1

Initially, bits 5-7 are all set to 1's. Note that for each alteration of the Delta Limits Parameter set, the left-most "1" is each time set to zero.

Before entering the values into the EPROM, the user must append bits 7,6,5 to the left of bits 4,3,2,1,0 to obtain one eight-bit binary word. The equivalent hexadecimal value should be looked up in the conversion table located in Appendix I. This is the value that should be programmed in the EPROM at address FB5.

Example: Assume that the Parameter Directory Register has to be set so that the third Input/Output user-defined parameter set is selected and the second Delta Limits user-defined parameter set is selected. The Parameter Directory Register should then appear as follows:

Bit Position	7	6	5	4	3	2	1	0
Value	0	1	1	1	1	1	0	0

As indicated by the binary value above, the Parameter Directory Register located at address FB5 should hold hexadecimal value 7C.

As long as the "user-defined combination" is selected via the switches (as indicated in Tables 6 and 7), the values in the Parameter Directory Register are interpreted. If these switches are set for one of the preprogrammed parameter sets, then the settings in the Parameter Directory Register are ignored.

Note also that because of the nature of EPROM programming, zeroes cannot be set to one. Therefore, once a user-defined parameter set has been used, and another one subsequently programmed, the previous user-defined parameter set may never be accessed again since there is no way of indicating this in the Parameter Directory Register.

7.5 USER-DEFINED INPUT/OUTPUT PARAMETERS

A hexadecimal code defines the input/output characteristics for a given analog input as follows:

Hexadecimal Code	Input	Output
5	unused	unused
9	± 1V	raw
A	± 1V	integral
B	± 1V	derivative
D	4-20 mA	raw
E	4-20 mA	integral
F	4-20 mA	derivative

Each of the hexadecimal codes above uniquely define the input/output characteristics of a given input. To assign a value to one of the inputs (groups), this hexadecimal code must be placed in the proper location in the EPROM memory. Groups C-H have their input/output parameters located in three consecutive bytes (8 bits) of memory. Tables 10 and 11 indicate their relative and absolute memory locations.

Table 10. Format of Input/Output Parameter Bytes

Bit 7 to Bit 4	Bit 3 to Bit 0
<-Group C - ->	<-Group D - ->

Bit 7 to Bit 4	Bit 3 to Bit 0
<-Group E - ->	<-Group F - ->

Bit 7 to Bit 4	Bit 3 to Bit 0
<-Group G - ->	<-Group H - ->

7.6 DETERMINING INPUT/OUTPUT PARAMETER ADDRESSES

When using an EPROM Programmer a hexadecimal memory address is required. This is needed in order to define the specific location in which the data (parameter value) is to be placed in the EPROM.

The memory address for each parameter byte varies with the number of user-defined parameter sets previously entered. Refer to Table 11 for the address of each byte in the Input/Output Parameter Set. If the user wishes to enter a user-defined parameter address he must specify the addresses which appear in column one of Table 11. If at some later time the user wishes to make further changes to the parameter set, he must specify addresses which appear in column 2 of the table (and adjust the AI-6 Parameter Directory Register accordingly).

The user may enter a total of five user-defined input/output parameter sets, but must specify the proper address as they correspond to the parameter set number. When using the FLN2317A EPROM Programmer (and HP 86A/87A/87XM or IBM PC computer) with the FLN4364A or FLN4365A Analog Input Utility Program, it is not necessary to know parameter addresses or hexadecimal codes.

Table 11. Input/Output Parameters Address Table

	User-Defined Parameter Set Number				
Group	1	2	3	4	5
C, D	FE3	FE6	FE9	FEC	FEF
E, F	FE4	FE7	FEA	FED	FF0
G, H	FE5	FE8	FEB	FEE	FF1

7.7 USER-DEFINED DELTA LIMIT ASSIGNMENTS

A hexadecimal code defines the delta limit assignment for a given analog input as follows:

Hexadecimal Code	Delta Limit Assignment
0	continuous tx.
1	1%
2	2%
3	5%
4	10%
5	25%
6	40%
7	infinity (no tx)

Each of the hexadecimal codes above, uniquely defines the delta limit assignment of a given input. To assign a value to one of the inputs (groups), this code must be placed in the proper EPROM memory location. Delta limit assignments for groups C-H are located in three consecutive bytes of EPROM memory. The format of these bytes is the same as the format illustrated by Table 10.

7.8 DETERMINING DELTA LIMIT PARAMETER ADDRESSES

Refer to Table 12, for the address of the location of delta limit assignments. As in Input/Output parameters, the user must specify the correct address which depends on the number of alterations previously made. If the user enters the first user-defined Delta Limit Parameter Set, the addresses are those which appear in column 1. If another set is entered, the addresses which appear in column 2 are used. A total of three Delta Limit Parameter Sets may be entered on the same EPROM.

Table 12. Delta Limit Parameter Address Table

	User-Defined Parameter Set Number		
Group	1	2	3
C, D	FAC	FAF	FB2
E, F	FAD	FB0	FB3
G, H	FAE	FB1	FB4

MOTOROLA INC.
Communications Sector

THEORY OF OPERATION

1. GENERAL DESCRIPTION

The Analog Input module (AI-6) converts analog data into digital information and is capable of accepting up to six current or voltage analog inputs. It processes the analog information according to user-selectable parameters and transfers the resulting digital data to the MRU Encoder module.

2. BLOCK DIAGRAM DESCRIPTION

Refer to Figure 1, Analog Input Module Block Diagram. The user analog outputs (TB1) are connected to user connector J1 and are referred to as AN1 to AN6.

A **Surge Protection** circuit is connected directly to the analog input and has the purpose of filtering data and clamping surges that may exist on J1 inputs.

The analog data is transferred to the **Multiplexer Circuits (MUX)**, whose purpose is to transfer one input channel at a time to the **Instrumentation Amplifier.** The selection of the input channel to be processed is performed by the **Group** Selector.

The digital data produced by the **A/D Converter** is read by the **Microprocessor System,** which performs scaling , offsetting and computing of data, according to the parameters provided by the **Parameter Selection Circuitry,** and transfers it to the encoder module via bus connector (J2).

In the event that the AI-6 module is working in a very noisy environment and the program "runs away," or the RAM contents are illegally changed, the **Watchdog Timer** circuitry resets the microprocessor system and module operation starts from the beginning.

A **Voltage Regulator** circuit accepts the 12 Vdc input from the bus connector and provides four voltages to the module: +5V, +2.5V reference voltage, +8V and -7.3V.

3. DETAILED DESCRIPTION

3.1 INPUT CIRCUITRY

The analog data is received at the six inputs AN1 to AN6, located on user connector J1, pins 1 to 12. All the inputs accept data in differential mode and are floating.

Resistors R1 to R6 depend on the type of input - current or voltage and have the following values:

Current input	62.6 Ohms, ±0.1%
Voltage input	10 K Ohms, ±5%

The default factory setting is for **current** input. The protection circuit consists of two 20K ohm resistors (resistor networks U1, U7, U13) connected in series with each input, 12 RF

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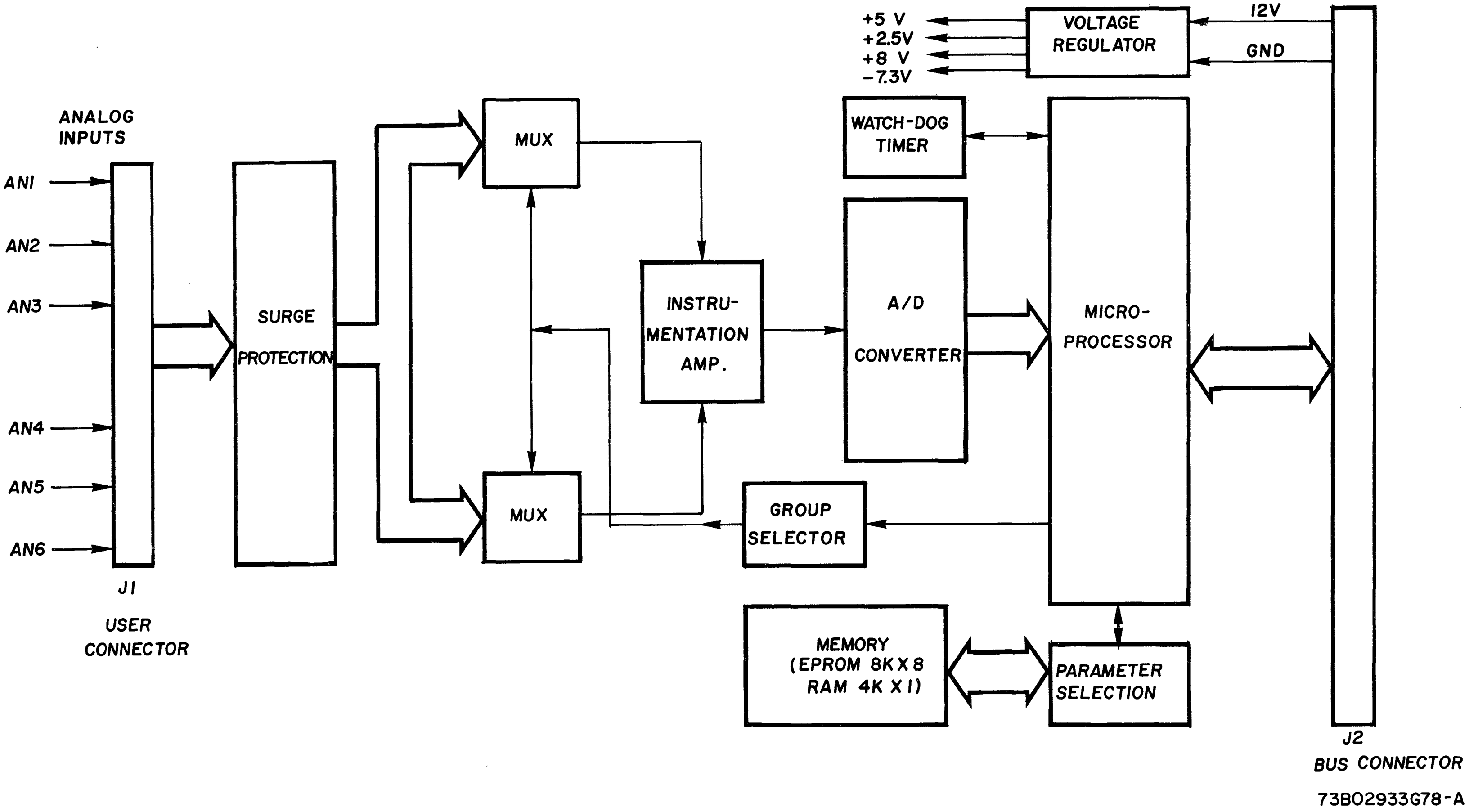


Figure 1. Analog Input Module Block Diagram

capacitors (C1-C12) and hybrid circuit U22. U22 contains filtering capacitors (0.1uF and 0.01uF) and four clamping diodes forming a bridge, for each input.

3.2 DATA ROUTING

Multiplexers U10 and U14 select each analog input, sequentially, to the input of instrumentation amplifier U8. The channel whose data is to be transferred is chosen by group selector U18.

Apart from the six input channels, two more readings are done through the MUX: 1-Volt reference (U10, pin 2 and U14, pin 2) taken from the wiper of potentiometer R19, and ground reading (U10, pin 4 and U14, pin 4). These readings are necessary for scaling and offsetting of data.

The output of instrumentation amplifier (U8, pin 8) is level shifted by 1.1V by adding the analog data to a fixed positive voltage from U8, pin 7.

3.3 A/D CONVERSIONS

The analog-to-digital conversion is performed by the 3-1/2 digit A/D converter (U2). It receives the analog data at pin 3 and performs a ratiometric conversion, and produces the multiplexed BCD outputs (Q0-Q3, pins 20-23) and the digit select output (DS4-DS1, pins 16-19). The device clock frequency can be adjusted by using potentiometer R40. The integration circuit consists of C33 and R41. The reference voltage used by the A/D converter is received at pin 2 and is 2.5 V.

3.4 PROCESSING UNIT

The processing unit consists of microprocessor U3, 8Kx8 EPROM (U11), 1Kx4 RAM (U19), address latch (U15) and the memory enable circuitry (U9 and U12).

3.4.1 Microprocessor

The MC146805E2 microprocessor has 16 bi-directional input/output lines designated PA0 - PA7 and PB0 - PB7. The microprocessor uses these lines to monitor and control the activities of the other circuit blocks. It contains an onchip oscillator which uses an external 4.37 MHz ceramic resonator. The microprocessor has 127 bytes scratch-pad memory. In order to reduce power consumption, the microprocessor periodically enters "sleep mode." It "wakes up" each time (82 or 68.3 ms for 50 or 60 Hz operation, respectively) and performs its tasks in approximately 3 ms. The microprocessor will also "wake up" if there is a bus request. During a bus request, the worst-case operation time is approximately 30 ms.

The microprocessor receives the digital information from the A/D converter at Port A (PA7 to PA0, pins 7-14). Lines PA0 and PA1 of port A are also used as outputs during the reading of parameters. Port B is used as follows:

PB0, PB3, PB4, PB6 and PB7 are used for bus communication with the MRU Encoder module.

PB1 is used to provide the clock for the group selector via inverting switch Q9.

PB2 is used to accept the parameters in serial form.

PB5 is used to reset the Watchdog Timer.

The end-of-conversion (EOC) pulse issued by the A/D converter (U2, pin 14) is connected to the input timer (U3, pin 37) and causes a timer interrupt every time the analog conversion is finished. This instructs the microprocessor to read the digital data which exists at port A.

Bus communication with the MRU Encoder module is initiated when a hardware interrupt is received at input IRQ (U3, pin 2). The bus interface consists of six lines which are connected to the I/O ports of the microprocessor through series protection resistors R11-R15 and pull-up resistor network U4. They are:

Microprocessor Port	Bus Connector
PB6	READY
PB0	DATA
PB4	CLOCK
PB3	ADDRESS
PB7	BREQ

When communication takes place, the MRU pulls the BUSY line low and releases it only when communication has ended. The MRU communicates to the AI-6 module by placing the unit's unique address on the ADDR line. The two units begin communicating through an interlocked series of signals on the bus which assures complete handshake between them.

3.4.2 EPROM

The microprocessor addresses an externally connected 8K EPROM where program and parameters reside. Lines B0 - B7 multiplex the data bus and eight lower address bits. Lines A8 - A11 output the upper address bits. Address lines are brought out to a 28-pin socket which can accept memory of 8K. The EPROM is enabled to function with the 4K upper address out of the 8K space.

3.4.3 RAM

The microprocessor addresses an externally connected 1Kx4 RAM in addition to the internal scratch-pad memory. Lines B0 - B7 multiplex the data bus and eight lower address bits. A8 - A9 output the upper address bits.

3.4.4 Address Latch

In order to avoid conflict between signals on the multiplexed address/data bus, latch register U15 is used. When a valid address appears at input D0 - D7, an address strobe signal (AS) generated by the microprocessor causes the address to be loaded into the latch.

3.4.5 Memory Enable

The memory enable circuitry provides the chip enable for the EPROM (CE) and RAM (E), write enable for the RAM (W), and output enable (OE) for the EPROM. The microprocessor provides the data strobe (DS), read/write (R/W) and A12 signals needed by the memory enable circuitry, which consists of U9 and U12.

3.5 GROUP SELECTOR

When the EOC pulse is issued, shift register U18 is reset via inverter U9 and transistor Q8. The microprocessor then clocks the shift register via transistor Q9 in order to enable the next channel.

3.6 PARAMETER SELECTION

There are two possible parameter-selection configurations for the AI-6 module. In one configuration, the parameters are determined by a single 9-station DIP switch (S1). In the other configuration, the parameters are determined by two rotary switches (S1 and S2) and 2-station DIP switch (S3).

The switch settings are read into shift register U5 upon receiving PRMLD (Parameter Load) pulse from the microprocessor. The microprocessor clocks U5 by issuing pulse PRMCLK (parameter clock). The output of U5 is read serially through PB2.

3.7 INTERRUPT DETECTOR

The Interrupt Detector provides a 20 us negative-going pulse necessary to initiate bus communication with the MRU Encoder module, whenever the BUSY line (J2/6) goes low. This pulse is provided by the circuit consisting of inverters U9 and gate U16. Because the edge detection is performed by an integrating configuration (C19, R21), this circuit has good noise immunity.

3.8 WATCHDOG TIMER

The Watchdog Timer circuit is used to prevent program runaway and transmission lock-up. It has an autonomous oscillator/timer (U20) and the circuit is designed to set its output approximately one second after being reset. If this time period elapses, the output of U20 will go low and a reset pulse to the microprocessor will be generated.

Under normal conditions the microprocessor periodically (A/D conversion cycle period) executes a code which generates a reset pulse through PB5 which resets the count in U20. In this case, the output of U20 is normally high since it is reset by the microprocessor before the two second period expires.

However, if the program runs away, chances are that the microprocessor will not execute the short sequence of instructions which generates the reset pulse to the Watchdog Timer. The timer will continue to count freely and, when 1 second elapses, will generate a reset pulse to the microprocessor which will initiate a software reset to the system.

3.9 VOLTAGE REGULATOR

The power required by the AI-6 module is received from the MRU Encoder module via the flat cable connected at J2: J2-15,16(+) and J2-10,11 (common). This voltage can be 11 to 14 V. The Voltage Regulator provides the four voltages required by the Analog Input module: +5V, +2.5V, +8V and -7.3V.

3.9.1 5-Volt Regulator

The purpose of this circuit block is to regulate the input voltage to 5 Volts dc in order to properly supply the logic circuits. The regulator has a low standby current of 80 uA. The voltage output is temperature compensated and is accurate to better than ±5%. VR5 and Q4 base emitter junction are used as a reference voltage. Q4 controls the gate voltage of Q5, thus creating a closed loop which regulates the output voltage. The fine adjustment to the voltage is made by using potentiometer R46. The regulator is current limited and prevents the CMOS logic from entering SCR mode by using a fold-back current limiter technique implemented by Q3 and its accompanying discrete components.

3.9.2 2.5-Volt Regulator

This circuit consists of U17 and provides the reference for the A/D converter (U2) and the 1-Volt reference circuits (R18, R19, R20).

3.9.3 8-Volt Regulator

The 8-Volt regulator provides a regulated 8 V output used by the shift register (U18), the instrumentation amplifier (U8) and the multiplexers (U10 and U14). The regulation is obtained by controlling the base current of Q6 by changes in Q7 collector current. The reference Zener is VR6.

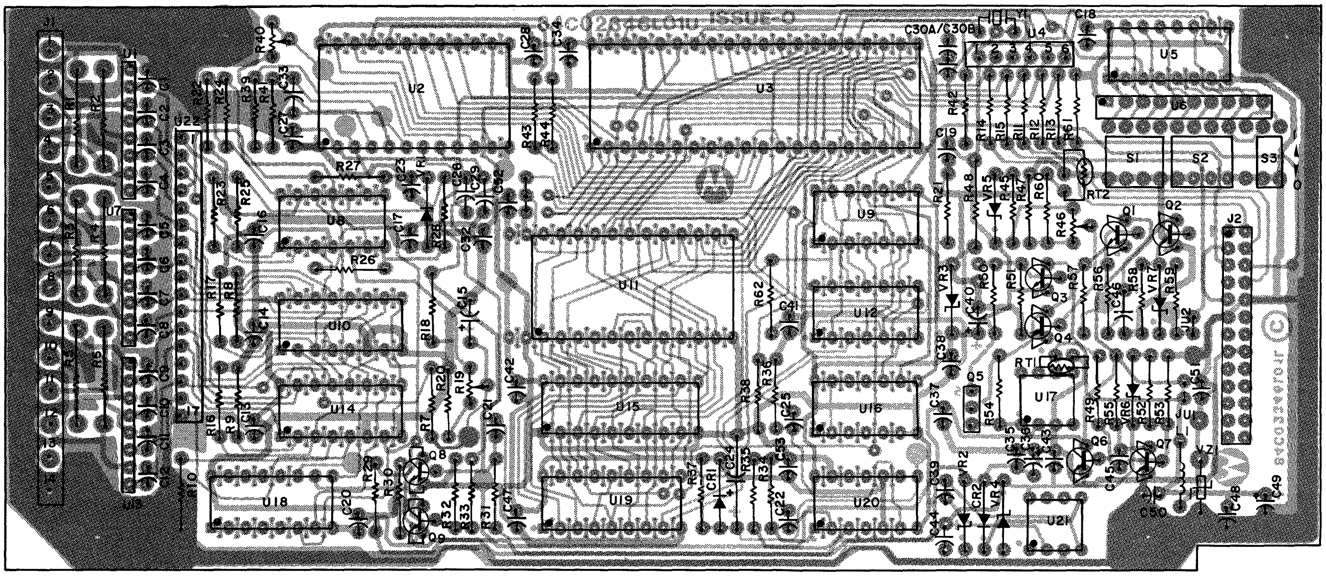
3.9.4 -7.3-Volt Regulator

The circuit provides a regulated -7.3 V output used by U10, U14 and U2. It is obtained at the output of voltage converter U21 (at the anode of diode CR2).

3.9.5 Power Switch

The Power Switch is optional and can be used by connecting jumper JU2 and disconnecting jumper JU3. If a power fail occurs, this switch will disable the AI-6 module in order to reserve the battery for MRU encoder operation only.

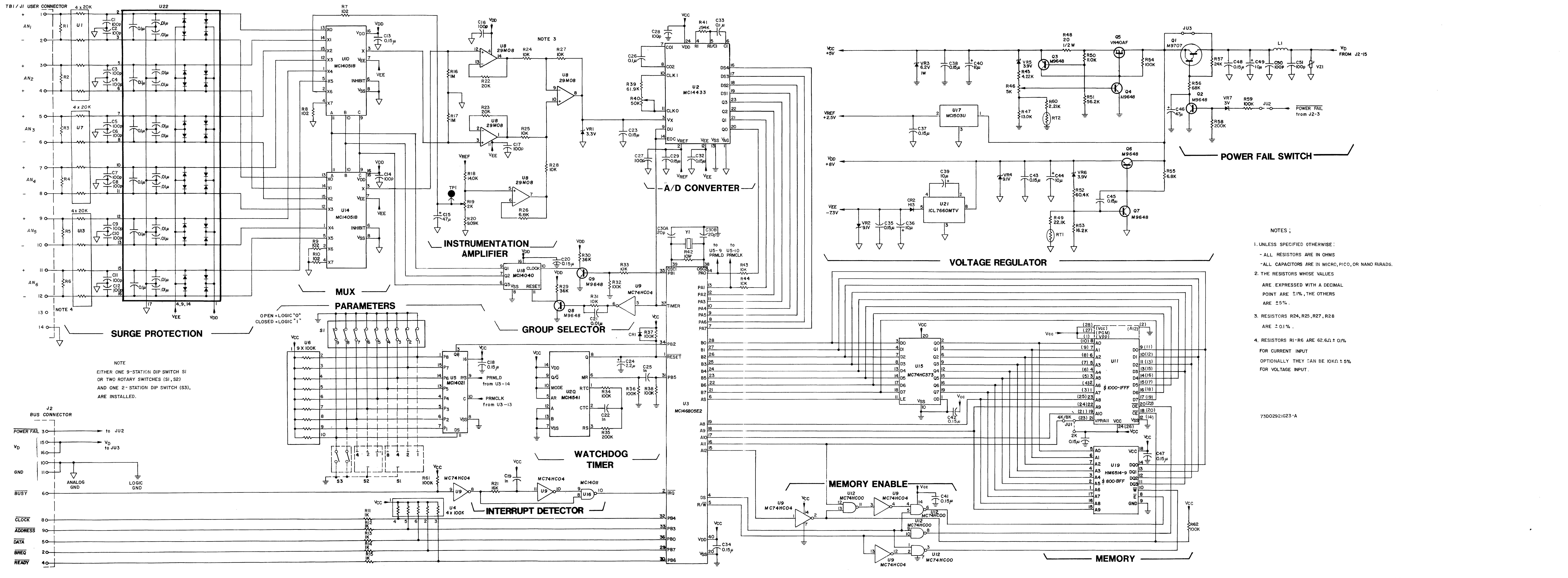
A +5V voltage received at J2-3 from the Encoder module saturates transistor Q2, which in turn, causes saturation of Q1 and voltage VD to be connected to the AI-6 module. If the voltage at J2-3 drops to less than 3V, Q2 turns off, turning off Q1 and the AI-6 module will cease drawing current from the battery.



SHOWN FROM COMPONENT SIDE

OVERLAY ●79B02934G48-0
SOLDER SIDE ◎79B02934G49-0
COMPONENT SIDE◎79B02934G50-0

FLN4345A MRU Analog Input
Printed Circuit Board Detail
February, 1986



NOTE

EITHER ONE 9-STATION DIP SWITCH S1
OR TWO ROTARY SWITCHES (S1, S2)
AND ONE 2-STATION DIP SWITCH (S3),
ARE INSTALLED.

NOTES;

1. UNLESS SPECIFIED OTHERWISE:
   - ALL RESISTORS ARE IN OHMS
   - ALL CAPACITORS ARE IN MICRO, PICO, OR NANO FARADS.
2. THE RESISTORS WHOSE VALUES ARE EXPRESSED WITH A DECIMAL POINT ARE ±1%, THE OTHERS ARE ±5%.
3. RESISTORS R24, R25, R27, R28 ARE ±0.1%.
4. RESISTORS R1-R6 ARE 62.6Ω ± 0.1% FOR CURRENT INPUT
   OPTIONALLY THEY CAN BE 10KΩ ± 5% FOR VOLTAGE INPUT.

73D02921G23-A

FLN4345A MRU Analog Input
Schematic Diagram
February, 1986

parts lists

FLN4345A AI6 Main Board PL-0342-O

Reference Symbol	Motorola Part No.	Description
		Capacitors
C1-C12	21-05455G01	100 pF 50 V
C13, C14	21-84008H03	.15 uF 50 V
C15	23-84538G06	47 uF 20 V
C16, C17	21-05455G01	100 pF 50 V
C18	21-84008H03	.15 uF 50 V
C19	21-83162H09	1000 pF 25 V
C20	21-84008H03	.15 uF 50 V
C21	21-84008H01	.01 uF 50 V
C22	21-83162H09	1000 pF 25 V
C23	21-84008H03	.15 uF 50 V
C24	23-84762H04	2.2 uF 25 V
C25	21-83162H09	1000 pF 25 V
C26	08-02083C52	.1 uF ±10% 63 V
C27, C28	21-05455G01	100 pF 50 V
C29	21-84008H03	.15 uF 50 V
C30a,C30b		part of Y1
C32	21-84008H03	100 pF 50 V
C33	08-02083C52	.1 uF ±10% 63 V
C34, C35	21-84008H03	.15 uF 50 V
C36	23-84538G10	10 uF 20 V
C37, C38	21-84008H03	.15 uF 50 V
C39, C40	23-84538G10	10 uF 20 V
C41-C43	21-84008H03	.15 uF 50 V
C44	23-84538G10	10 uF 20 V
C45	21-84008H03	.15 uF 50 V
C46	23-84538G06	47 uF 20 V
C47, C48	21-84008H03	.15 uF 50 V
C49	23-84665F01	10 uF 25 V
C50, C51	21-05455G01	100 pF 50 V
C52, C53	21-84008H03	.15 uF 50 V
		Diodes
CR1	48-83654H01	silicon signal
CR2	48-82466H13	silicon rectifier
		Connectors
J1	28-08044H06	26 pins
J2	28-08508G04	14 pins
		Coil
L1	24-82723H11	.2 uH
		Transistors
Q1	48-00869707	PNP Darlington, M9707
Q2-Q4	48-00869648	NPN, M9648
Q5	48-08237G04	VFET, VN40AF
Q6-Q9	48-00869648	NPN, M9648
		Resistors:ohms ±5% 1/4 W unless otherwise stated
R1-R6	06-08563C10	62.2 ±.1% 1/2 W
R7-R10	06-10621A98	102 ±1% 1/4 W
R11-R15	06-11009C49	1000
R16, R17	06-10621E85	1M ±1% 1/4 W
R18	06-02478C69	14k ±1% 1/10 W
R19	18-02467C02	2k, potentiometer
R20	06-02478C51	9.09k ±1% 1/10 W
R21	06-11009C78	16k
R22, R23	06-10621D21	20k ±1% 1/10 W
R24, R25	06-02478C55	10k ±1% 1/10 W
R26	06-10621C71	6.19k ±1% 1/10 W
R27,R28	06-02478C55	10k ±1% 1/4 W
R29, R30	06-11009C86	36k
R31	06-11009C73	10k
R32	06-11009C97	100k
R33	06-11009C73	10k
R34	06-11009C97	100k
R35	06-11009D05	200k
R36-R38	06-11009C97	100k
R39	06-10621D68	61.9 ±1% 1/4 W
R40	18-02467C29	50k, potentiometer
R41	06-10621E34	294k ±1% 1/4 W
R42	06-00124B46	10M
R43, R44	06-11009C73	10k
R45	06-10621C55	4.22k ±1% 1/4 W
R46	18-02467C32	5k, potentiometer
R47	06-10621D03	13k ±1% 1/4 W
R48	06-00125A08	20 ±5% 1/2 W
R49	06-10621D25	22.1k ±1% 1/4 W
R50	06-10621C95	11k ±1% 1/4 W
R51	06-10621D64	56.2k ±1% 1/4 W
R52	06-10621D67	60.4k ±1% 1/4 W
R53	06-10621D12	16.2k ±1% 1/4 W
R54	06-11009C97	100k
R55	06-11009C69	6800
R56	06-11009C93	6.8k
R57	06-11009C82	24k
R58	06-11009D05	200k
R59	06-11009C97	100k
R60	06-10621C28	2210 ±1% 1/4 W
R61, R62	06-11009C97	100k
		Thermistors
RT1, RT2	06-83600K06	10k ohms ±5% @ 25° C
		Switches
S1	40-02406H03	rotary, 16 positions
S2	40-02406H04	rotary, 10 positions
S3	40-02235C09	DIP, 2 stations
		Integrated circuits
U1	51-02599K25	resistor array, 20k x 4
U2	51-02581K46	MC14433BCL
U3	51-02187C24	MC146805E2CL
U4	51-02599K10	resistor array, 100k x 5
U5	51-02073C44	MC14021BCL
U6	51-02599K01	resistor array, 100k x 9
U7	51-02599K25	resistor array, 20k x 4
U8	51-83629M08	29M08
U9	51-08244G33	MC74HCU04J
U10	51-02073C61	MC14051BCL
U11	51-02156C35	NM27C32QE-45
U12	51-08244G05	MC74HC00J
U13	51-02599K25	resistor array, 20k x 4
U14	51-02073C61	MC14051BCL
U15	51-08244G03	74HC373
U16	51-02209C05	MC14011BCL
U17	51-02162C59	MC1503U
U18	51-02073C32	MC14040BCL
U19	51-02156C19	6514: 1024 x 4
U20	51-02073C39	MC14541
U21	51-02162C51	ICL7660MTV
U22	51-08381H01	hybrid
		Zener diodes
VR1	48-82256C26	3.3 V
VR2	48-82256C43	9.1 V
VR3	48-83461E36	6.2 V
VR4	48-82256C43	9.1 V
VR5, VR6	48-02064C82	3.9 V
VR7	48-08322H04	3 V
		Varistor
VZ1	06-02597K14	22 V dc
		Crystal
Y1	48-08565C02	4.37 MHz, includes C30
		Hardware
	84-02346L01	printed circuit board

Note: To maintain specified performance, all parts **must** be ordered by Motorola part numbers.

FLN4436A EPROM Kit PL-0344-O

Reference Symbol	Motorola Part No.	Description
	51-02156C37	CMOS EPROM, 8k x 8 MBM2764-30X

FLN5720 Hardware PL-0345-O

Reference Symbol	Motorola Part No.	Description
	01-02717G06	Terminal and Wire Assembly, includes:
	29-02231C07	terminal lug
	03-00129675	lock screw, 4-40x1/4, 2 used
	03-00134309	lock screw, 4-40x3/16
	03-08026H02	captive screw, 8-32x3/4, 2 used
	03-08302H01	tapping screw, 2 used
	31-08509G04	terminal with socket
	54-08125H01	connector label

FLN4347A Housing PL-0346-O

Reference Symbol	Motorola Part No.	Description
	02-02427C01	lock nut, 4-40x1x.22"
	03-08026H05	captive screw, 8-32x7/8, 2 used
	03-82210E15	captive screw, 2 used
	15-08513H01	housing base
	15-08586G01	housing cover
	15-08587G01	housing door
	22-02482C02	dowel pin
	54-08049K01	parameter label
	54-08124H01	address label
	54-08635G04	front label

MOTOROLA INC.
Communications Sector

MAINTENANCE

1. DISASSEMBLY

Refer to the disassembly instructions located in the 68P02933G43 Installation section of this manual when:

a. Changing jumper settings

b. Changing parameter settings in the EPROM

c. Performing adjustments

d. Changing input usage resistors.

2. JUMPERS AND PARAMETERS

To change jumper settings on the PC board or parameter values on the EPROM, refer to the 68P02933G43 Installation section of this manual.

3. ADJUSTMENTS

To prepare the AI-6 module for adjustments, the unit must be disassembled in order to expose the board.

- The flat cable between the AI-6 and MRU must then be connected as described in the 68P02933G43 Installation section, paragraph 6.2, Bus Connection.
- Parameter switches (S1 or S1, S2, S3) should all be set to zero.
- The MRU must be connected to power.
- The MRU should be connected to the C1570A,71A Test Set, (refer to the 68P02933G20 MRU Encoder Instruction Manual, 68P02933G56 Maintenance section, paragraphs 5 and 6).

3.1 VCC ADJUSTMENT

Attach the positive terminal of a voltmeter to the cathode of VR3 and the negative terminal to ground. Adjust potentiometer R46 so that the meter reading is 5 volts (± 0.01V).

3.2 1-VOLT REFERENCE

Connect a 12 mA current source to input C (pin 1, 2) of User Connector J1 and adjust R19 until the analog reading for group C on the test set is "000" on the decimal display module and LEDs 16-25 of the Test Set are extinguished (0).

3.3 A/D CLOCK

To set the analog-to-digital converter clock frequency, connect a frequency counter between U2-11 (by using an IC clip) and ground. The counter should be connected via a probe having an impedance of 10M ohm 20 pF. Adjust R40 to obtain a reading of:

200 KHz ± 0.1% for 50 Hz mains
240 KHz ± 0.1% for 60 Hz mains.

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4. CHANGING INPUT USAGE

The AI-6 board is preset at the factory for current input usage (4-20 mA) with resistors R1 to R6 rated 62.6 ohms, ± 0.1%.

To select voltage input usage (±1V), the corresponding resistors must be replaced with ones that are rated 10K ohms, ± 5%.

Refer to the 68P02933G43 Installation section of this manual, Analog Input Connections, Table 3.

5. FAULT LOCALIZING

The information presented in this paragraph is intended to help localize malfunctions that may occur.

5.1 VOLTAGES

Check the various voltages according to table 1, below.

Table 1. AI-6 Voltages

Symbol	Value
VD	10 to 15 V
VCC	4.9 to 5.1 V
VDD	7.5 to 8.3 V
VEE	-6.5 to -7.7 V
VREF	2.475 to 2.525 V
TP1	0.95 to 1.05 V

If the voltages are all zero, check that the Power Fail switch is not activated. (In normal operation, jumper JU3 must be closed and jumper JU2 open.)

5.2 ANALOG INPUT MALFUNCTION

a. Verify that the use of the particular input conforms to the settings of the parameter DIP switches S1 (or S1, S2, S3).

b. Verify that resistors R1 - R6 are rated according to the input usage selected (see paragraph 4 above).

c. Reset the AI-6 by disconnecting and reconnecting the flat bus cable between the AI-6 module and the MRU Encoder module and again verify the operation of the analog inputs.

d. Check each analog input sequentially in order to localize the malfunction. If all of the inputs are defective, continue to step (e) below. If some of the inputs (but not all) are defective, check multiplexers U10, U14 and the discrete components pertaining to that input.

e. Check the 1-Volt reference and the analog-digital clock at U2-11, as described in paragraphs 3.2 and 3.3 above.

f. Check the input to the A/D converter (U2-3) with an oscilloscope. The waveform must be a constant 1V DC with 2V peaks of approximately 80 ms, about every 600 ms, (if the user inputs are open). If the waveform differs from this, check the multiplexers U10, U14, instrumentation amplifier U8, group selector U18 and associated circuitry.

g. Check that the EOC output of the A/D converter (U2-14) has 2 us pulses with a period of 82 ms or 68.3 ms (for 50 or 60 Hz mains frequency, respectively).

h. Check that at the output PB1 (U3/35) appear bursts of 1,2,3...7 pulses.

i. Check that the Watchdog Timer output (U20-8) is constant up. If not, check that its Master Reset (U20-6) receives 20 us pulses approximately every 80 ms.

j. Check that whenever the BUSY line (J2-6) goes low, a negative-going 10 us pulse is obtained at U3-2.

APPENDIX I

Decimal-Binary-Hexadecimal Conversion Table

Dec	Binary	Hex	Dec	Binary	Hex	Dec	Binary	Hex
0	00000000	00	85	01010101	55	170	10101010	AA
1	00000001	01	86	01010110	56	171	10101011	AB
2	00000010	02	87	01010111	57	172	10101100	AC
3	00000011	03	88	01011000	58	173	10101101	AD
4	00000100	04	89	01011001	59	174	10101110	AE
5	00000101	05	90	01011010	5A	175	10101111	AF
6	00000110	06	91	01011011	5B	176	10110000	B0
7	00000111	07	92	01011100	5C	177	10110001	B1
8	00001000	08	93	01011101	5D	178	10110010	B2
9	00001001	09	94	01011110	5E	179	10110011	B3
10	00001010	0A	95	01011111	5F	180	10110100	B4
11	00001011	0B	96	01100000	60	181	10110101	B5
12	00001100	0C	97	01100001	61	182	10110110	B6
13	00001101	0D	98	01100010	62	183	10110111	B7
14	00001110	0E	99	01100011	63	184	10111000	B8
15	00001111	0F	100	01100100	64	185	10111001	B9
16	00010000	10	101	01100101	65	186	10111010	BA
17	00010001	11	102	01100110	66	187	10111011	BB
18	00010010	12	103	01100111	67	188	10111100	BC
19	00010011	13	104	01101000	68	189	10111101	BD
20	00010100	14	105	01101001	69	190	10111110	BE
21	00010101	15	106	01101010	6A	191	10111111	BF
22	00010110	16	107	01101011	6B	192	11000000	C0
23	00010111	17	108	01101100	6C	193	11000001	C1
24	00011000	18	109	01101101	6D	194	11000010	C2
25	00011001	19	110	01101110	6E	195	11000011	C3
26	00011010	1A	111	01101111	6F	196	11000100	C4
27	00011011	1B	112	01110000	70	197	11000101	C5
28	00011100	1C	113	01110001	71	198	11000110	C6
29	00011101	1D	114	01110010	72	199	11000111	C7
30	00011110	1E	115	01110011	73	200	11001000	C8
31	00011111	1F	116	01110100	74	201	11001001	C9
32	00100000	20	117	01110101	75	202	11001010	CA
33	00100001	21	118	01110110	76	203	11001011	CB
34	00100010	22	119	01110111	77	204	11001100	CC
35	00100011	23	120	01111000	78	205	11001101	CD
36	00100100	24	121	01111001	79	206	11001110	CE
37	00100101	25	122	01111010	7A	207	11001111	CF
38	00100110	26	123	01111011	7B	208	11010000	D0
39	00100111	27	124	01111100	7C	209	11010001	D1
40	00101000	28	125	01111101	7D	210	11010010	D2
41	00101001	29	126	01111110	7E	211	11010011	D3
42	00101010	2A	127	01111111	7F	212	11010100	D4
43	00101011	2B	128	10000000	80	213	11010101	D5
44	00101100	2C	129	10000001	81	214	11010110	D6
45	00101101	2D	130	10000010	82	215	11010111	D7
46	00101110	2E	131	10000011	83	216	11011000	D8
47	00101111	2F	132	10000100	84	217	11011001	D9
48	00110000	30	133	10000101	85	218	11011010	DA
49	00110001	31	134	10000110	86	219	11011011	DB
50	00110010	32	135	10000111	87	220	11011100	DC
51	00110011	33	136	10001000	88	221	11011101	DD
52	00110100	34	137	10001001	89	222	11011110	DE
53	00110101	35	138	10001010	8A	223	11011111	DF
54	00110110	36	139	10001011	8B	224	11100000	E0
55	00110111	37	140	10001100	8C	225	11100001	E1
56	00111000	38	141	10001101	8D	226	11100010	E2
57	00111001	39	142	10001110	8E	227	11100011	E3
58	00111010	3A	143	10001111	8F	228	11100100	E4
59	00111011	3B	144	10010000	90	229	11100101	E5
60	00111100	3C	145	10010001	91	230	11100110	E6
61	00111101	3D	146	10010010	92	231	11100111	E7
62	00111110	3E	147	10010011	93	232	11101000	E8
63	00111111	3F	148	10010100	94	233	11101001	E9
64	01000000	40	149	10010101	95	234	11101010	EA
65	01000001	41	150	10010110	96	235	11101011	EB
66	01000010	42	151	10010111	97	236	11101100	EC
67	01000011	43	152	10011000	98	237	11101101	ED
68	01000100	44	153	10011001	99	238	11101110	EE
69	01000101	45	154	10011010	9A	239	11101111	EF
70	01000110	46	155	10011011	9B	240	11110000	F0
71	01000111	47	156	10011100	9C	241	11110001	F1
72	01001000	48	157	10011101	9D	242	11110010	F2
73	01001001	49	158	10011110	9E	243	11110011	F3
74	01001010	4A	159	10011111	9F	244	11110100	F4
75	01001011	4B	160	10100000	A0	245	11110101	F5
76	01001100	4C	161	10100001	A1	246	11110110	F6
77	01001101	4D	162	10100010	A2	247	11110111	F7
78	01001110	4E	163	10100011	A3	248	11111000	F8
79	01001111	4F	164	10100100	A4	249	11111001	F9
80	01010000	50	165	10100101	A5	250	11111010	FA
81	01010001	51	166	10100110	A6	251	11111011	FB
82	01010010	52	167	10100111	A7	252	11111100	FC
83	01010011	53	168	10101000	A8	253	11111101	FD
84	01010100	54	169	10101001	A9	254	11111110	FE
						255	11111111	FF

APPENDIX II

```
INPUT (mA)   3.840   3.872   3.904   3.936   3.968   4.000   4.032   4.064
OUTPUT       -510    -508    -506    -504    -502    -500    -498    -496

INPUT (mA)   4.096   4.128   4.160   4.192   4.224   4.256   4.288   4.320
OUTPUT       -494    -492    -490    -488    -486    -484    -482    -480

INPUT (mA)   4.352   4.384   4.416   4.448   4.480   4.512   4.544   4.576
OUTPUT       -478    -476    -474    -472    -470    -468    -466    -464

INPUT (mA)   4.608   4.640   4.672   4.704   4.736   4.768   4.800   4.832
OUTPUT       -462    -460    -458    -456    -454    -452    -450    -448

INPUT (mA)   4.864   4.896   4.928   4.960   4.992   5.024   5.056   5.088
OUTPUT       -446    -444    -442    -440    -438    -436    -434    -432

INPUT (mA)   5.120   5.152   5.184   5.216   5.248   5.280   5.312   5.344
OUTPUT       -430    -428    -426    -424    -422    -420    -418    -416

INPUT (mA)   5.376   5.408   5.440   5.472   5.504   5.536   5.568   5.600
OUTPUT       -414    -412    -410    -408    -406    -404    -402    -400

INPUT (mA)   5.632   5.664   5.696   5.728   5.760   5.792   5.824   5.856
OUTPUT       -398    -396    -394    -392    -390    -388    -386    -384

INPUT (mA)   5.888   5.920   5.952   5.984   6.016   6.048   6.080   6.112
OUTPUT       -382    -380    -378    -376    -374    -372    -370    -368

INPUT (mA)   6.144   6.176   6.208   6.240   6.272   6.304   6.336   6.368
OUTPUT       -366    -364    -362    -360    -358    -356    -354    -352

INPUT (mA)   6.400   6.432   6.464   6.496   6.528   6.560   6.592   6.624
OUTPUT       -350    -348    -346    -344    -342    -340    -338    -336

INPUT (mA)   6.656   6.688   6.720   6.752   6.784   6.816   6.848   6.880
OUTPUT       -334    -332    -330    -328    -326    -324    -322    -320

INPUT (mA)   6.912   6.944   6.976   7.008   7.040   7.072   7.104   7.136
OUTPUT       -318    -316    -314    -312    -310    -308    -306    -304

INPUT (mA)   7.168   7.200   7.232   7.264   7.296   7.328   7.360   7.392
OUTPUT       -302    -300    -298    -296    -294    -292    -290    -288

INPUT (mA)   7.424   7.456   7.488   7.520   7.552   7.584   7.616   7.648
OUTPUT       -286    -284    -282    -280    -278    -276    -274    -272

INPUT (mA)   7.680   7.712   7.744   7.776   7.808   7.840   7.872   7.904
OUTPUT       -270    -268    -266    -264    -262    -260    -258    -256

INPUT (mA)   7.936   7.968   8.000   8.032   8.064   8.096   8.128   8.160
OUTPUT       -254    -252    -250    -248    -246    -244    -242    -240

INPUT (mA)   8.192   8.224   8.256   8.288   8.320   8.352   8.384   8.416
OUTPUT       -238    -236    -234    -232    -230    -228    -226    -224

INPUT (mA)   8.448   8.480   8.512   8.544   8.576   8.608   8.640   8.672
OUTPUT       -222    -220    -218    -216    -214    -212    -210    -208

INPUT (mA)   8.704   8.736   8.768   8.800   8.832   8.864   8.896   8.928
OUTPUT       -206    -204    -202    -200    -198    -196    -194    -192
```

```
INPUT (mA)  8.960   8.992   9.024   9.056   9.088   9.120   9.152   9.184
OUTPUT      -1.90   -1.88   -1.86   -1.84   -1.82   -1.80   -1.78   -1.76

INPUT (mA)  9.216   9.248   9.280   9.312   9.344   9.376   9.408   9.440
OUTPUT      -1.74   -1.72   -1.70   -1.68   -1.66   -1.64   -1.62   -1.60

INPUT (mA)  9.472   9.504   9.536   9.568   9.600   9.632   9.664   9.696
OUTPUT      -1.58   -1.56   -1.54   -1.52   -1.50   -1.48   -1.46   -1.44

INPUT (mA)  9.728   9.760   9.792   9.824   9.856   9.888   9.920   9.952
OUTPUT      -1.42   -1.40   -1.38   -1.36   -1.34   -1.32   -1.30   -1.28

INPUT (mA)  9.984  10.016  10.048  10.080  10.112  10.144  10.176  10.208
OUTPUT      -1.26   -1.24   -1.22   -1.20   -1.18   -1.16   -1.14   -1.12

INPUT (mA) 10.240  10.272  10.304  10.336  10.368  10.400  10.432  10.464
OUTPUT      -1.10   -1.08   -1.06   -1.04   -1.02   -1.00    -98     -96

INPUT (mA) 10.496  10.528  10.560  10.592  10.624  10.656  10.688  10.720
OUTPUT       -94     -92     -90     -88     -86     -84     -82     -80

INPUT (mA) 10.752  10.784  10.816  10.848  10.880  10.912  10.944  10.976
OUTPUT       -78     -76     -74     -72     -70     -68     -66     -64

INPUT (mA) 11.008  11.040  11.072  11.104  11.136  11.168  11.200  11.232
OUTPUT       -62     -60     -58     -56     -54     -52     -50     -48

INPUT (mA) 11.264  11.296  11.328  11.360  11.392  11.424  11.456  11.488
OUTPUT       -46     -44     -42     -40     -38     -36     -34     -32

INPUT (mA) 11.520  11.552  11.584  11.616  11.648  11.680  11.712  11.744
OUTPUT       -30     -28     -26     -24     -22     -20     -18     -16

INPUT (mA) 11.776  11.808  11.840  11.872  11.904  11.936  11.968  12.000
OUTPUT       -14     -12     -10      -8      -6      -4      -2       0

INPUT (mA) 12.032  12.064  12.096  12.128  12.160  12.192  12.224  12.256
OUTPUT         2       4       6       8      10      12      14      16

INPUT (mA) 12.288  12.320  12.352  12.384  12.416  12.448  12.480  12.512
OUTPUT        18      20      22      24      26      28      30      32

INPUT (mA) 12.544  12.576  12.608  12.640  12.672  12.704  12.736  12.768
OUTPUT        34      36      38      40      42      44      46      48

INPUT (mA) 12.800  12.832  12.864  12.896  12.928  12.960  12.992  13.024
OUTPUT        50      52      54      56      58      60      62      64

INPUT (mA) 13.056  13.088  13.120  13.152  13.184  13.216  13.248  13.280
OUTPUT        66      68      70      72      74      76      78      80

INPUT (mA) 13.312  13.344  13.376  13.408  13.440  13.472  13.504  13.536
OUTPUT        82      84      86      88      90      92      94      96

INPUT (mA) 13.568  13.600  13.632  13.664  13.696  13.728  13.760  13.792
OUTPUT        98    1.00    1.02    1.04    1.06    1.08    1.10    1.12

INPUT (mA) 13.824  13.856  13.888  13.920  13.952  13.984  14.016  14.048
OUTPUT      1.14    1.16    1.18    1.20    1.22    1.24    1.26    1.28
```

INPUT (mA)	14.080	14.112	14.144	14.176	14.208	14.240	14.272	14.304
OUTPUT	130	132	134	136	138	140	142	144
INPUT (mA)	14.336	14.368	14.400	14.432	14.464	14.496	14.528	14.560
OUTPUT	146	148	150	152	154	156	158	160
INPUT (mA)	14.592	14.624	14.656	14.688	14.720	14.752	14.784	14.816
OUTPUT	162	164	166	168	170	172	174	176
INPUT (mA)	14.848	14.880	14.912	14.944	14.976	15.008	15.040	15.072
OUTPUT	178	180	182	184	186	188	190	192
INPUT (mA)	15.104	15.136	15.168	15.200	15.232	15.264	15.296	15.328
OUTPUT	194	196	198	200	202	204	206	208
INPUT (mA)	15.360	15.392	15.424	15.456	15.488	15.520	15.552	15.584
OUTPUT	210	212	214	216	218	220	222	224
INPUT (mA)	15.616	15.648	15.680	15.712	15.744	15.776	15.808	15.840
OUTPUT	226	228	230	232	234	236	238	240
INPUT (mA)	15.872	15.904	15.936	15.968	16.000	16.032	16.064	16.096
OUTPUT	242	244	246	248	250	252	254	256
INPUT (mA)	16.128	16.160	16.192	16.224	16.256	16.288	16.320	16.352
OUTPUT	258	260	262	264	266	268	270	272
INPUT (mA)	16.384	16.416	16.448	16.480	16.512	16.544	16.576	16.608
OUTPUT	274	276	278	280	282	284	286	288
INPUT (mA)	16.640	16.672	16.704	16.736	16.768	16.800	16.832	16.864
OUTPUT	290	292	294	296	298	300	302	304
INPUT (mA)	16.896	16.928	16.960	16.992	17.024	17.056	17.088	17.120
OUTPUT	306	308	310	312	314	316	318	320
INPUT (mA)	17.152	17.184	17.216	17.248	17.280	17.312	17.344	17.376
OUTPUT	322	324	326	328	330	332	334	336
INPUT (mA)	17.408	17.440	17.472	17.504	17.536	17.568	17.600	17.632
OUTPUT	338	340	342	344	346	348	350	352
INPUT (mA)	17.664	17.696	17.728	17.760	17.792	17.824	17.856	17.888
OUTPUT	354	356	358	360	362	364	366	368
INPUT (mA)	17.920	17.952	17.984	18.016	18.048	18.080	18.112	18.144
OUTPUT	370	372	374	376	378	380	382	384
INPUT (mA)	18.176	18.208	18.240	18.272	18.304	18.336	18.368	18.400
OUTPUT	386	388	390	392	394	396	398	400
INPUT (mA)	18.432	18.464	18.496	18.528	18.560	18.592	18.624	18.656
OUTPUT	402	404	406	408	410	412	414	416
INPUT (mA)	18.688	18.720	18.752	18.784	18.816	18.848	18.880	18.912
OUTPUT	418	420	422	424	426	428	430	432
INPUT (mA)	18.944	18.976	19.008	19.040	19.072	19.104	19.136	19.168
OUTPUT	434	436	438	440	442	444	446	448

```
INPUT (mA) 19.200   19.232   19.264   19.296   19.328   19.360   19.392   19.424
OUTPUT       450      452      454      456      458      460      462      464

INPUT (mA) 19.456   19.488   19.520   19.552   19.584   19.616   19.648   19.680
OUTPUT       466      468      470      472      474      476      478      480

INPUT (mA) 19.712   19.744   19.776   19.808   19.840   19.872   19.904   19.936
OUTPUT       482      484      486      488      490      492      494      496

INPUT (mA) 19.968   20.000   20.032   20.064   20.096   20.128   20.160
OUTPUT       498      500      502      504      506      508      510
```

APPENDIX III

```
INPUT (V)   -1.020   -1.016   -1.012   -1.008   -1.004   -1.000   -0.996   -0.992
OUTPUT      -510     -508     -506     -504     -502     -500     -498     -496

INPUT (V)   -0.988   -0.984   -0.980   -0.976   -0.972   -0.968   -0.964   -0.960
OUTPUT      -494     -492     -490     -488     -486     -484     -482     -480

INPUT (V)   -0.956   -0.952   -0.948   -0.944   -0.940   -0.936   -0.932   -0.928
OUTPUT      -478     -476     -474     -472     -470     -468     -466     -464

INPUT (V)   -0.924   -0.920   -0.916   -0.912   -0.908   -0.904   -0.900   -0.896
OUTPUT      -462     -460     -458     -456     -454     -452     -450     -448

INPUT (V)   -0.892   -0.888   -0.884   -0.880   -0.876   -0.872   -0.868   -0.864
OUTPUT      -446     -444     -442     -440     -438     -436     -434     -432

INPUT (V)   -0.860   -0.856   -0.852   -0.848   -0.844   -0.840   -0.836   -0.832
OUTPUT      -430     -428     -426     -424     -422     -420     -418     -416

INPUT (V)   -0.828   -0.824   -0.820   -0.816   -0.812   -0.808   -0.804   -0.800
OUTPUT      -414     -412     -410     -408     -406     -404     -402     -400

INPUT (V)   -0.796   -0.792   -0.788   -0.784   -0.780   -0.776   -0.772   -0.768
OUTPUT      -398     -396     -394     -392     -390     -388     -386     -384

INPUT (V)   -0.764   -0.760   -0.756   -0.752   -0.748   -0.744   -0.740   -0.736
OUTPUT      -382     -380     -378     -376     -374     -372     -370     -368

INPUT (V)   -0.732   -0.728   -0.724   -0.720   -0.716   -0.712   -0.708   -0.704
OUTPUT      -366     -364     -362     -360     -358     -356     -354     -352

INPUT (V)   -0.700   -0.696   -0.692   -0.688   -0.684   -0.680   -0.676   -0.672
OUTPUT      -350     -348     -346     -344     -342     -340     -338     -336

INPUT (V)   -0.668   -0.664   -0.660   -0.656   -0.652   -0.648   -0.644   -0.640
OUTPUT      -334     -332     -330     -328     -326     -324     -322     -320

INPUT (V)   -0.636   -0.632   -0.628   -0.624   -0.620   -0.616   -0.612   -0.608
OUTPUT      -318     -316     -314     -312     -310     -308     -306     -304

INPUT (V)   -0.604   -0.600   -0.596   -0.592   -0.588   -0.584   -0.580   -0.576
OUTPUT      -302     -300     -298     -296     -294     -292     -290     -288

INPUT (V)   -0.572   -0.568   -0.564   -0.560   -0.556   -0.552   -0.548   -0.544
OUTPUT      -286     -284     -282     -280     -278     -276     -274     -272

INPUT (V)   -0.540   -0.536   -0.532   -0.528   -0.524   -0.520   -0.516   -0.512
OUTPUT      -270     -268     -266     -264     -262     -260     -258     -256

INPUT (V)   -0.508   -0.504   -0.500   -0.496   -0.492   -0.488   -0.484   -0.480
OUTPUT      -254     -252     -250     -248     -246     -244     -242     -240

INPUT (V)   -0.476   -0.472   -0.468   -0.464   -0.460   -0.456   -0.452   -0.448
OUTPUT      -238     -236     -234     -232     -230     -228     -226     -224

INPUT (V)   -0.444   -0.440   -0.436   -0.432   -0.428   -0.424   -0.420   -0.416
OUTPUT      -222     -220     -218     -216     -214     -212     -210     -208

INPUT (V)   -0.412   -0.408   -0.404   -0.400   -0.396   -0.392   -0.388   -0.384
OUTPUT      -206     -204     -202     -200     -198     -196     -194     -192
```

```
INPUT (V)    -0.380   -0.376   -0.372   -0.368   -0.364   -0.360   -0.356   -0.352
OUTPUT       -1.90    -1.88    -1.86    -1.84    -1.82    -1.80    -1.78    -1.76

INPUT (V)    -0.348   -0.344   -0.340   -0.336   -0.332   -0.328   -0.324   -0.320
OUTPUT       -1.74    -1.72    -1.70    -1.68    -1.66    -1.64    -1.62    -1.60

INPUT (V)    -0.316   -0.312   -0.308   -0.304   -0.300   -0.296   -0.292   -0.288
OUTPUT       -1.58    -1.56    -1.54    -1.52    -1.50    -1.48    -1.46    -1.44

INPUT (V)    -0.284   -0.280   -0.276   -0.272   -0.268   -0.264   -0.260   -0.256
OUTPUT       -1.42    -1.40    -1.38    -1.36    -1.34    -1.32    -1.30    -1.28

INPUT (V)    -0.252   -0.248   -0.244   -0.240   -0.236   -0.232   -0.228   -0.224
OUTPUT       -1.26    -1.24    -1.22    -1.20    -1.18    -1.16    -1.14    -1.12

INPUT (V)    -0.220   -0.216   -0.212   -0.208   -0.204   -0.200   -0.196   -0.192
OUTPUT       -1.10    -1.08    -1.06    -1.04    -1.02    -1.00      -98      -96

INPUT (V)    -0.188   -0.184   -0.180   -0.176   -0.172   -0.168   -0.164   -0.160
OUTPUT         -94      -92      -90      -88      -86      -84      -82      -80

INPUT (V)    -0.156   -0.152   -0.148   -0.144   -0.140   -0.136   -0.132   -0.128
OUTPUT         -78      -76      -74      -72      -70      -68      -66      -64

INPUT (V)    -0.124   -0.120   -0.116   -0.112   -0.108   -0.104   -0.100   -0.096
OUTPUT         -62      -60      -58      -56      -54      -52      -50      -48

INPUT (V)    -0.092   -0.088   -0.084   -0.080   -0.076   -0.072   -0.068   -0.064
OUTPUT         -46      -44      -42      -40      -38      -36      -34      -32

INPUT (V)    -0.060   -0.056   -0.052   -0.048   -0.044   -0.040   -0.036   -0.032
OUTPUT         -30      -28      -26      -24      -22      -20      -18      -16

INPUT (V)    -0.028   -0.024   -0.020   -0.016   -0.012   -0.008   -0.004   -0.000
OUTPUT         -14      -12      -10       -8       -6       -4       -2       -0

INPUT (V)     0.004    0.008    0.012    0.016    0.020    0.024    0.028    0.032
OUTPUT          2        4        6        8       10       12       14       16

INPUT (V)     0.036    0.040    0.044    0.048    0.052    0.056    0.060    0.064
OUTPUT         18       20       22       24       26       28       30       32

INPUT (V)     0.068    0.072    0.076    0.080    0.084    0.088    0.092    0.096
OUTPUT         34       36       38       40       42       44       46       48

INPUT (V)     0.100    0.104    0.108    0.112    0.116    0.120    0.124    0.128
OUTPUT         50       52       54       56       58       60       62       64

INPUT (V)     0.132    0.136    0.140    0.144    0.148    0.152    0.156    0.160
OUTPUT         66       68       70       72       74       76       78       80

INPUT (V)     0.164    0.168    0.172    0.176    0.180    0.184    0.188    0.192
OUTPUT         82       84       86       88       90       92       94       96

INPUT (V)     0.196    0.200    0.204    0.208    0.212    0.216    0.220    0.224
OUTPUT         98     1.00     1.02     1.04     1.06     1.08     1.10     1.12

INPUT (V)     0.228    0.232    0.236    0.240    0.244    0.248    0.252    0.256
OUTPUT       1.14     1.16     1.18     1.20     1.22     1.24     1.26     1.28
```

```
INPUT (V)      0.260   0.264   0.268   0.272   0.276   0.280   0.284   0.288
OUTPUT         1.30    1.32    1.34    1.36    1.38    1.40    1.42    1.44

INPUT (V)      0.292   0.296   0.300   0.304   0.308   0.312   0.316   0.320
OUTPUT         1.46    1.48    1.50    1.52    1.54    1.56    1.58    1.60

INPUT (V)      0.324   0.328   0.332   0.336   0.340   0.344   0.348   0.352
OUTPUT         1.62    1.64    1.66    1.68    1.70    1.72    1.74    1.76

INPUT (V)      0.356   0.360   0.364   0.368   0.372   0.376   0.380   0.384
OUTPUT         1.78    1.80    1.82    1.84    1.86    1.88    1.90    1.92

INPUT (V)      0.388   0.392   0.396   0.400   0.404   0.408   0.412   0.416
OUTPUT         1.94    1.96    1.98    200     202     204     206     208

INPUT (V)      0.420   0.424   0.428   0.432   0.436   0.440   0.444   0.448
OUTPUT         210     212     214     216     218     220     222     224

INPUT (V)      0.452   0.456   0.460   0.464   0.468   0.472   0.476   0.480
OUTPUT         226     228     230     232     234     236     238     240

INPUT (V)      0.484   0.488   0.492   0.496   0.500   0.504   0.508   0.512
OUTPUT         242     244     246     248     250     252     254     256

INPUT (V)      0.516   0.520   0.524   0.528   0.532   0.536   0.540   0.544
OUTPUT         258     260     262     264     266     268     270     272

INPUT (V)      0.548   0.552   0.556   0.560   0.564   0.568   0.572   0.576
OUTPUT         274     276     278     280     282     284     286     288

INPUT (V)      0.580   0.584   0.588   0.592   0.596   0.600   0.604   0.608
OUTPUT         290     292     294     296     298     300     302     304

INPUT (V)      0.612   0.616   0.620   0.624   0.628   0.632   0.636   0.640
OUTPUT         306     308     310     312     314     316     318     320

INPUT (V)      0.644   0.648   0.652   0.656   0.660   0.664   0.668   0.672
OUTPUT         322     324     326     328     330     332     334     336

INPUT (V)      0.676   0.680   0.684   0.688   0.692   0.696   0.700   0.704
OUTPUT         338     340     342     344     346     348     350     352

INPUT (V)      0.708   0.712   0.716   0.720   0.724   0.728   0.732   0.736
OUTPUT         354     356     358     360     362     364     366     368

INPUT (V)      0.740   0.744   0.748   0.752   0.756   0.760   0.764   0.768
OUTPUT         370     372     374     376     378     380     382     384

INPUT (V)      0.772   0.776   0.780   0.784   0.788   0.792   0.796   0.800
OUTPUT         386     388     390     392     394     396     398     400

INPUT (V)      0.804   0.808   0.812   0.816   0.820   0.824   0.828   0.832
OUTPUT         402     404     406     408     410     412     414     416

INPUT (V)      0.836   0.840   0.844   0.848   0.852   0.856   0.860   0.864
OUTPUT         418     420     422     424     426     428     430     432

INPUT (V)      0.868   0.872   0.876   0.880   0.884   0.888   0.892   0.896
OUTPUT         434     436     438     440     442     444     446     448
```

```
INPUT (V)   0.900   0.904   0.908   0.912   0.916   0.920   0.924   0.928
OUTPUT      450     452     454     456     458     460     462     464

INPUT (V)   0.932   0.936   0.940   0.944   0.948   0.952   0.956   0.960
OUTPUT      466     468     470     472     474     476     478     480

INPUT (V)   0.964   0.968   0.972   0.976   0.980   0.984   0.988   0.992
OUTPUT      482     484     486     488     490     492     494     496

INPUT (V)   0.996   1.000   1.004   1.008   1.012   1.016   1.020
OUTPUT      498     500     502     504     506     508     510
```

INTRAC 2000
Modular Remote Unit
Analog Input

68P02933G40-O

MOTOROLA

INTRAC 2000®

Modular Remote Terminal Unit
Four Control Outputs

Instruction Manual

68P02962G50-O

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MOTOROLA INC.
Communications
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INTRAC 2000®

Modular Remote Terminal Unit

Four Control Outputs

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FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar types of equipment. It contains all service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date are incorporated by Instruction Manual Revisions (SMR). These SMR's are added to the manuals as the engineering changes are incorporated into the equipment.

2. MODEL AND KIT IDENTIFICATION

Motorola equipments are specifically identified by an overall model number on the nameplate. In most cases, assemblies and kits which make up the equipment also have kit model numbers stamped on them. When a production or engineering change is incorporated, the applicable schematic diagrams are updated.

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Orders for active filters, Vibrasender and Vibrasponder resonant reeds should specify type number and frequency, should identify the owner/operator of the communications system in which these items are to be used; and should include any serial numbers stamped on the components being replaced.

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2553 N. Edgington Street, Franklin Park, IL 60131
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Tel: 713-537-3636, TWX: 910-881-6392

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MOTOROLA INC.
Communications Sector

SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.
2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.
3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.
5. Use only a grounded soldering iron.
6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

   WARNING

   If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.

KIT BREAKDOWN

FLN1464A Four-Relay Control Output

- FLN4354A Main Board
- FLN5720A Hardware Main Board
- FLN4347A Modular Housing
- FLN4402A Label Kit
- 68P02962G50 Instruction Manual

SPECIFICATIONS

FOUR-RELAY CONTROL OUTPUT

GENERAL

Operating Voltage	5 V dc (through the MRTU Bus) 10-15 V dc (through the MRTU Bus)
Current Consumption	0.1 mA from 5 V dc input 0.1 mA from 10-15 V dc input
Output Protection	2.5 kV (IEEE 472 Standard)
Operating Temperature	-30°C to +60°C
Relative Humidity	0-90% without condensation
Dimensions	1.6" x 8.3" x 3.7" (H x W x D) 40.64 x 210.82 x 93.98 mm
Weight	400 g (0.9 lb.)

CONTROL OUTPUT

Output Type	Relays
Number of Relays	Four
Contact Rating	250 V ac 2 A max., 125 VA
Contact Type	Form C (changeover)
Relay Mode	Programmable (in the Basic module): latched, momentary general or common latched

MOTOROLA INC.

Communications
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GENERAL DESCRIPTION
CO-4

1. GENERAL

The MRTU FLN1464A Control Output Module (MRTU CO-4) is an expansion unit, which is configured with the Modular Remote Terminal Unit (MRTU). It receives execute codewords from the MRTU Basic Module via the common bus physically contained in the flat cable that interconnects all the MRTU Modules.

The CO-4 contains four relays, which are grouped in a control port and operate in the four following modes: general, momentary, latched and common latched. The control modes of the ports are programmed in the MRTU Basic Module, and may be altered by the user via the Field Configuration Program (refer to FRN1785 MRTU Field Configuration Program diskette).

The CO-4 is housed in a molded plastic housing. User-connection is provided by a removable screw-type terminal board ("user connector") at the bottom of the module.

During MRTU operation the CO-4 is attached to the MRTU Basic Module. For a description of MRTU operation, refer to FLN5003 MRTU Operation diskette.

1.1 POWER SOURCE

The CO-4 module is powered by the 5 V dc source (for CO-4 logic) and 12 V dc source (for relay drive) from the MRTU bus.

1.2 OPERATION

The CO-4 performs the following functions:

a. Activates its relays upon reception of an execute codeword from the MRTU Basic Module.

b. Presets its latched and common latched relays, and sets its momentary relays if a communication failure (CF) has occurred. The CF period and the relays to be preset are parameterized in the MRTU Basic Module.

c. The MRTU Basic Module resets the CO-4 relays upon power-up.

2. INSTALLATION

NOTE

Before connecting a module to the system via the flat cable assure that the system is disconnected from the electricity.

2.1 GENERAL

Normally, the CO-4 is installed at factory as an option of the MRTU, so there is no need for an installation procedure. When supplied as an add-on unit, follow the instructions in paragraphs 2.2 and 2.3.

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2.2 PRELIMINARY

Carefully inspect the CO-4 immediately upon receipt and notify the shipper of any damage incurred in transit. The installation procedure consists of mounting the housing and making the necessary external and internal connections.

2.3 MOUNTING

Mount the CO-4 on the mounting plate next to the other MRTU modules. Location of mounting holes is shown in Figure 2. Housing Detail. Connect the MRTU bus cable to the CO-4 bus connector.

2.4 DISASSEMBLY

To access the jumpers, the CO-4 must be disassembled. Follow the directions below for proper disassembly of the CO-4 housing (refer to Figure 3).

Step 1. Loosen the two captive screws that hold the module to the mounting plate (not visible).

Step 2. Loosen the two screws on the right panel of the CO-4 housing.

Step 3. Lift the latch door located at the top of the housing.

Step 4. Disconnect the MRTU bus (not visible).

Step 5. Gently separate the two sides and lift the back out of the three slots located to the rear of the unit. The PC board is now exposed.

2.5 ELECTRICAL CONNECTIONS

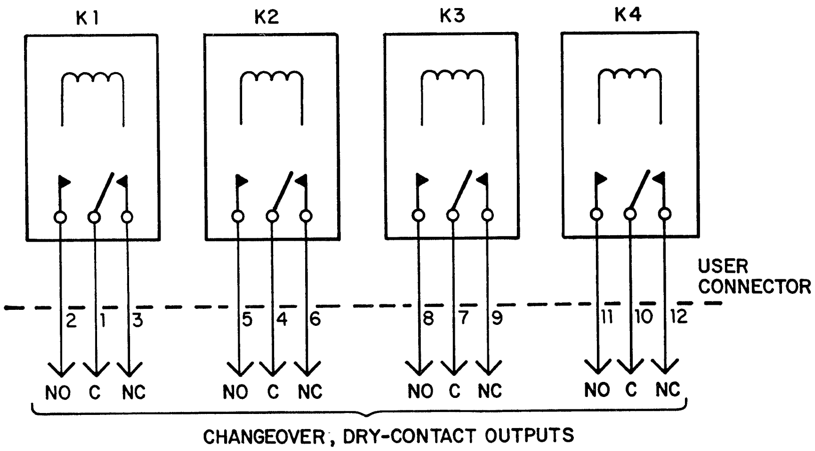
2.5.1 Jumper JU1

Changing jumper setting involves delicate work on the PC board. This operation is best performed first before any connections are made to the CO-4 module.

WARNING

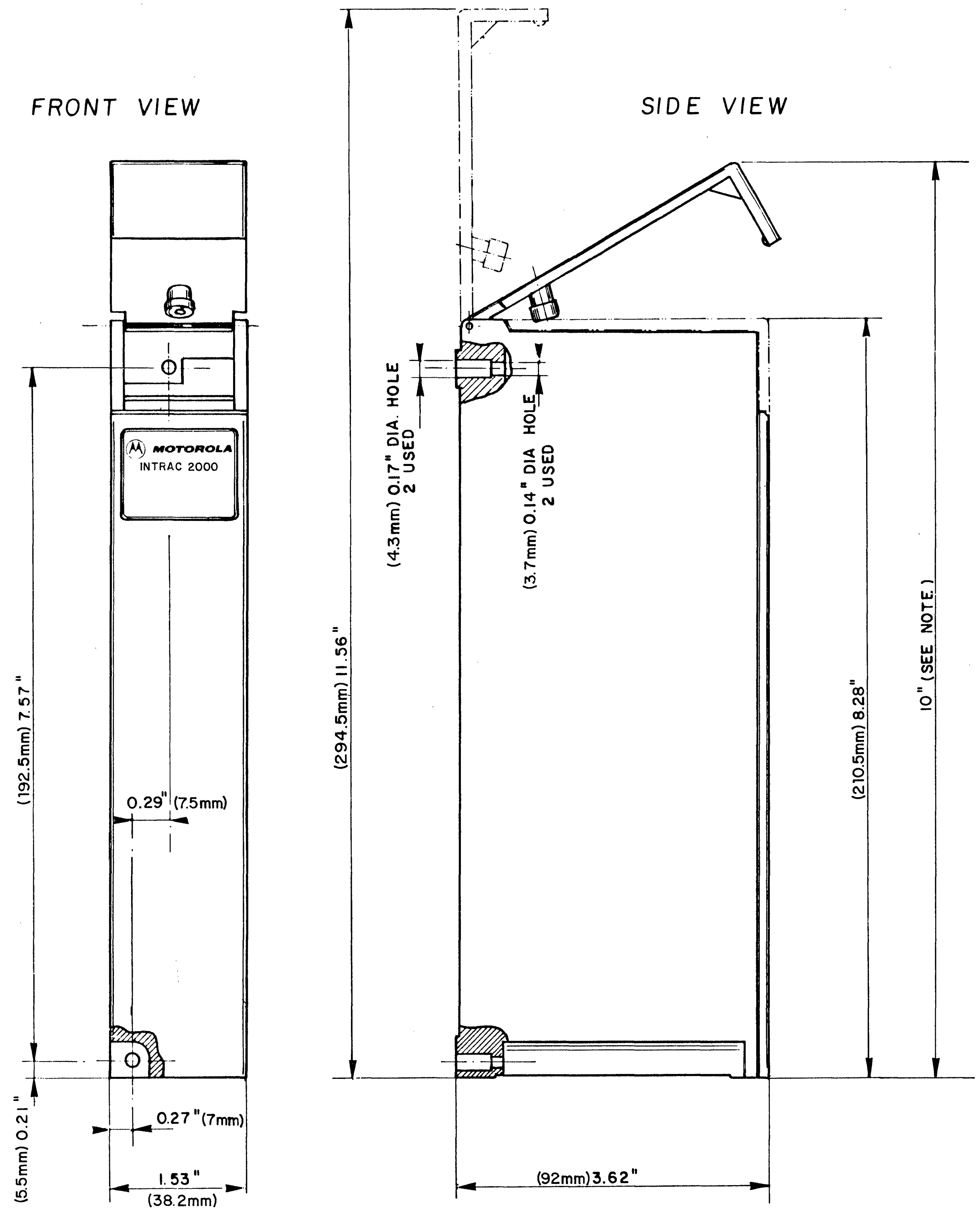
Touch the metal coating inside the housing before changing any jumper setting, to dissipate any static charge that might otherwise damage the CMOS integrated circuits.

To change the jumper-selectable port # do as follows: Locate jumper JU1 on the CO-4 board. It consists of eight rows of two pins, each one representing a different port #. Insert the mini-jumper into the desired port; the port # is thus selected.



73A02963G54-0

Figure 1. Control Outputs of CO-4 Module



NOTE

MINIMUM OPENING FOR REMOVING WIRE CONNECTOR.

73C02936G40-0

Figure 2. Housing Detail

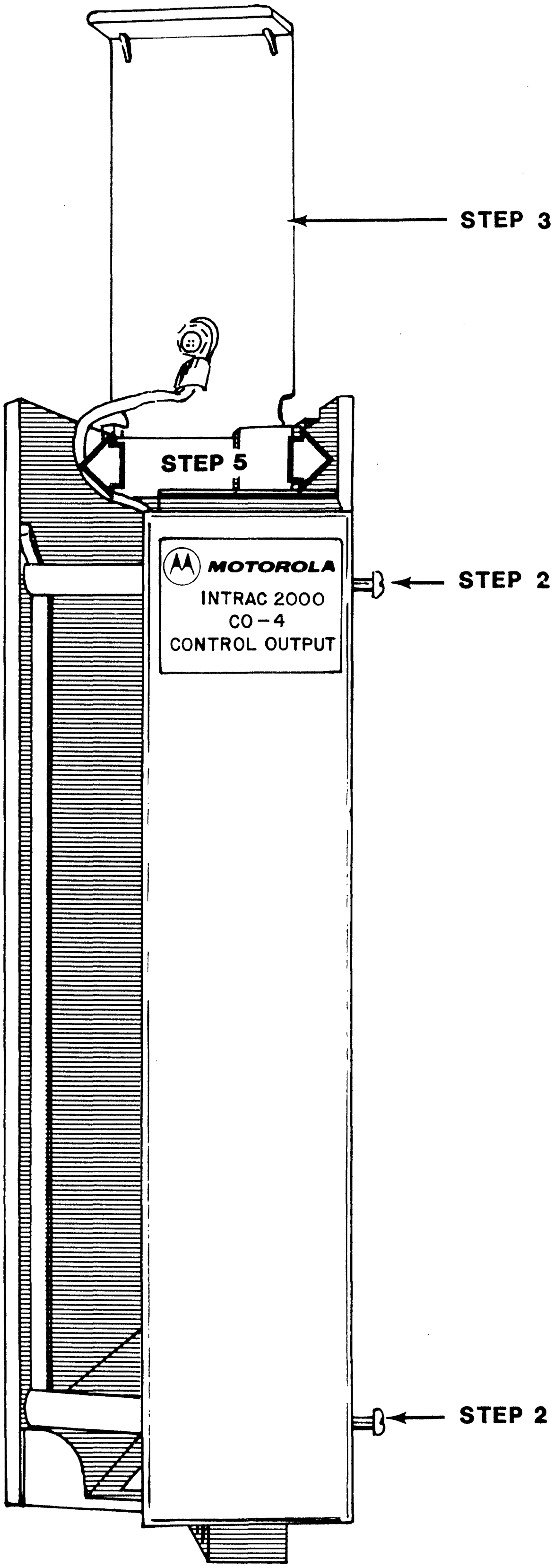


Figure 3. Disassembly

Table 1. Connector Functions

CONNECTOR	FUNCTION	DESCRIPTION
J1	Bus connector	Connects to the MRTU bus; contains 26 contacts (see schematic diagram).
J2	User connector	Connects the Control Output module to user devices; contains 14 pins, 3 for each relay (see schematic diagram).

2.5.2 Connectors

Two connectors are mounted on the PC board to allow interconnection to other modules in the MRTU and to user devices controlled by the MRTU.

The function of each connector is listed in Table 1. Locations of connectors are shown in Figure 4, CO-4 Printed Circuit Board.

3. THEORY OF OPERATION

3.1 GENERAL

For a comprehensive understanding of the circuit description, consult the schematic diagram together with the CO-4 block diagram at the end of this chapter.

Note that the bus interface with the MRTU Basic Module consists of four signal lines, which are connected to the I/O ports of the microprocessor through resistors R1-3. They are:

68HC11 Ports	Bus Connector
PA0	CKR
PA1	DATAR
PA2	OE
PA3	FBDATA

3.2 RELAY OPERATION MODE

NOTE

The following explanations refer to relay operation mode in the MRTU Basic Module and Output Control module.

The discrete control outputs are provided via relays that are switched by two pulses: one pulse for set operation ("Normally Closed" to "Common" contact) and another pulse for reset operation ("Normally Open" to "Common" contact). The relays are magnetically latched: the relay keeps its state (set or reset) without electrical power. All the relays have two sets of form C contacts: one set is for user application, the other serves as data feedback loop.

Activation of the relays is performed under control of the MRTU Basic Module (according to codewords that are received via the communication channel; refer to the FLN5003 Operation diskette).

The relays are grouped in ports, with four relays per port. Each port is assigned a "PORT #" (0-7) by means of a jumper (JU1).

Each port has its specific parameters programmed in the MRTU Basic Module EEPROM.

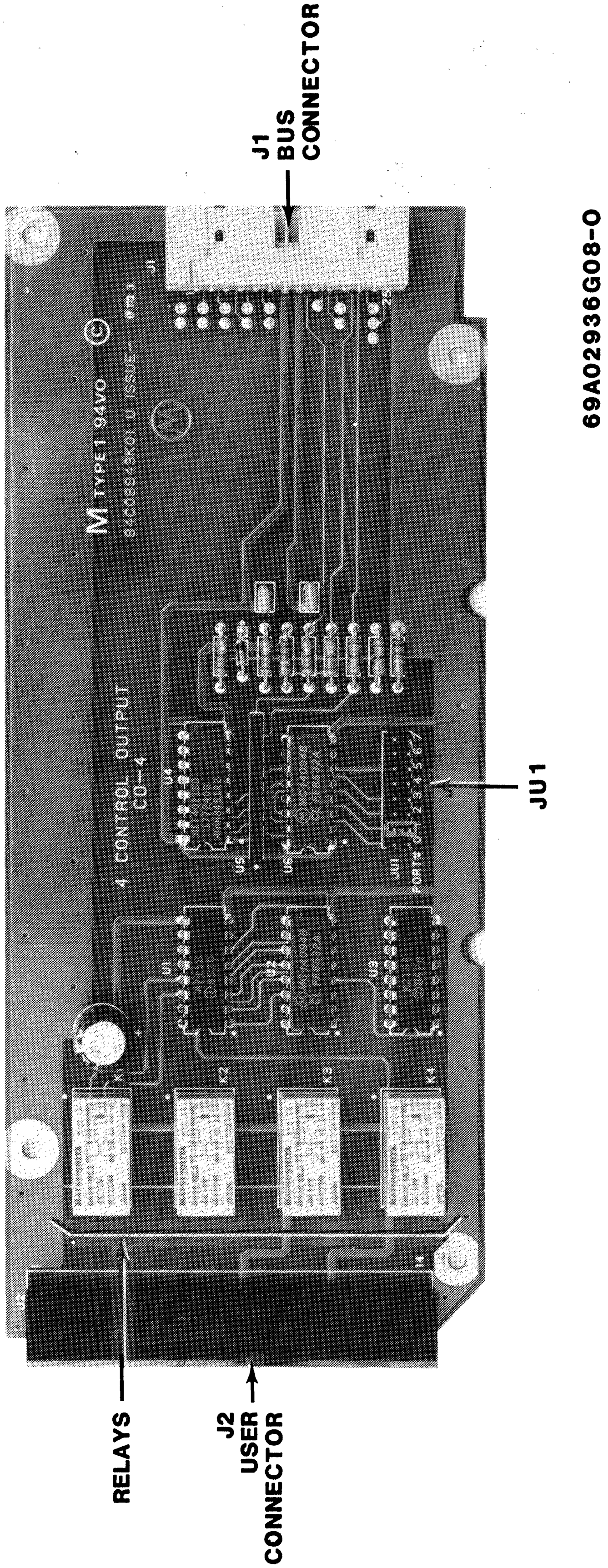


Figure 4. CO-4 Printed Circuit Board

3.2.1 Bus Communication for Relay Operation

NOTE

The procedure for relay activation and feedback explained below refers to the relays located in the Output Control modules.

Four signal lines on the bus are dedicated to relay operation:

OE	Output Enable; initiates relay triggering procedure.
DATAR	Data: port # and relay data.
CKR	Clock; clocks DATAR or FBDATA.
FBDATA	Feedback data; indicates relay status.

The Central Station transmits execute commands to the MRTU Basic Module for relay activation. Upon receipt of the INTRAC 2000 codeword, the MRTU Basic Module initiates the relay activation procedure by shifting data on the DATAR line and by pulling the OE line high.

The 16-bit codeword released by the MRTU Basic Module has the following format:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
K1		K2		K3		K4									
RELAY LATCH								PORT ADDRESS							

73A02934G93-0

Figure 5. Codeword for Relay Activation

where:

Bits 0-7	Contain data for relay activation.
Bits 8-15	Contain the port # bits. A "1" indicates port activation.

Relay feedback is received after the following 16-bit codeword has been serially transmitted by the MRTU Basic Module:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	PORT ADDRESS							

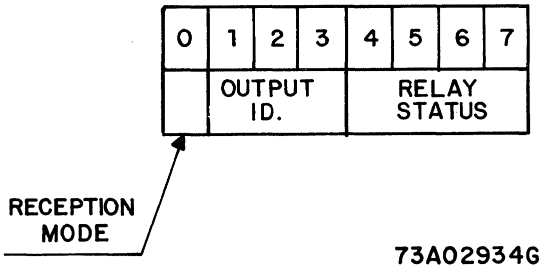
73A02934G91-0

Figure 6.
MRTU Basic Module Feedback

where:

Bits 0-7	Always zero (to prevent relay activation),
Bits 8-15	Indicate the port #.

Upon receipt of this request, the following 8-bit codeword is transmitted by the appropriate Control Output module:



0	1	2	3	4	5	6	7
	OUTPUT ID.			RELAY STATUS			

73A02934G92-0

Figure 7. Feedback Codeword

where:

Bits 1-3	Identify the output module: 0 0 1 designate the 4/8-Control Output modules.
Bits 4-7	Indicate the relay status.

4. MAINTENANCE

Failure diagnostic originates in the MRTU Basic Module. The MRTU Basic Module includes 8 LEDs connected to a test pushbutton.

During normal operation the LEDs will display the local inputs state. Pressing the test pushbutton will light the LEDs for 1 second and then the current error LEDs will light up.

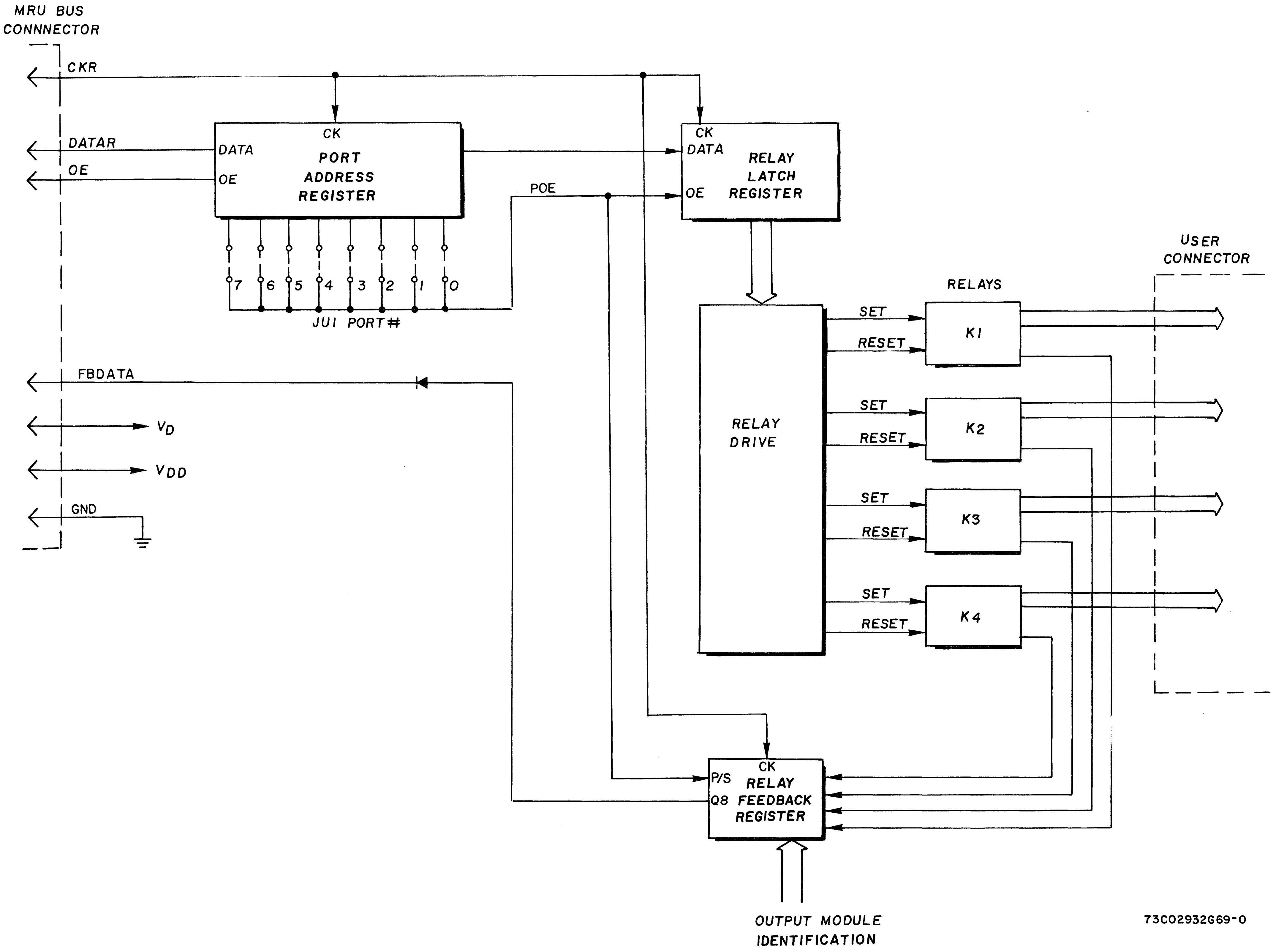
LED #4 indicates a relay back-indication failure, which signifies that an output relay is disabled. In order to identify the disabled relay do as follows:

Step 1. Disconnect all control output modules in the system.

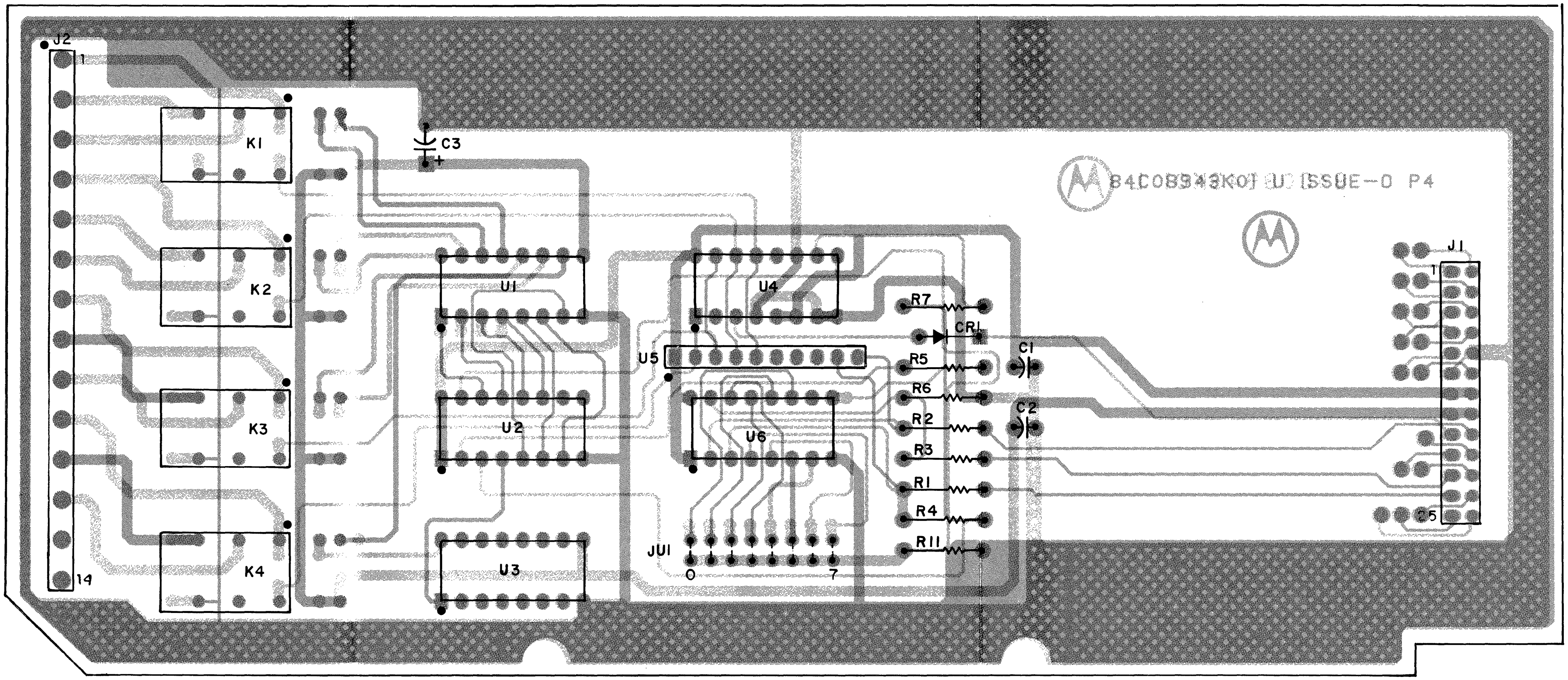
Step 2. Connect one control output module at a time and send a message via each relay to verify which relay is disabled.

Step 3. Press the test pushbutton on the MRTU Basic Module after each message to verify that the relay is working properly.

Step 4. When faulty relay is identified change the CO-4 or CO-8 module with the faulty relay.



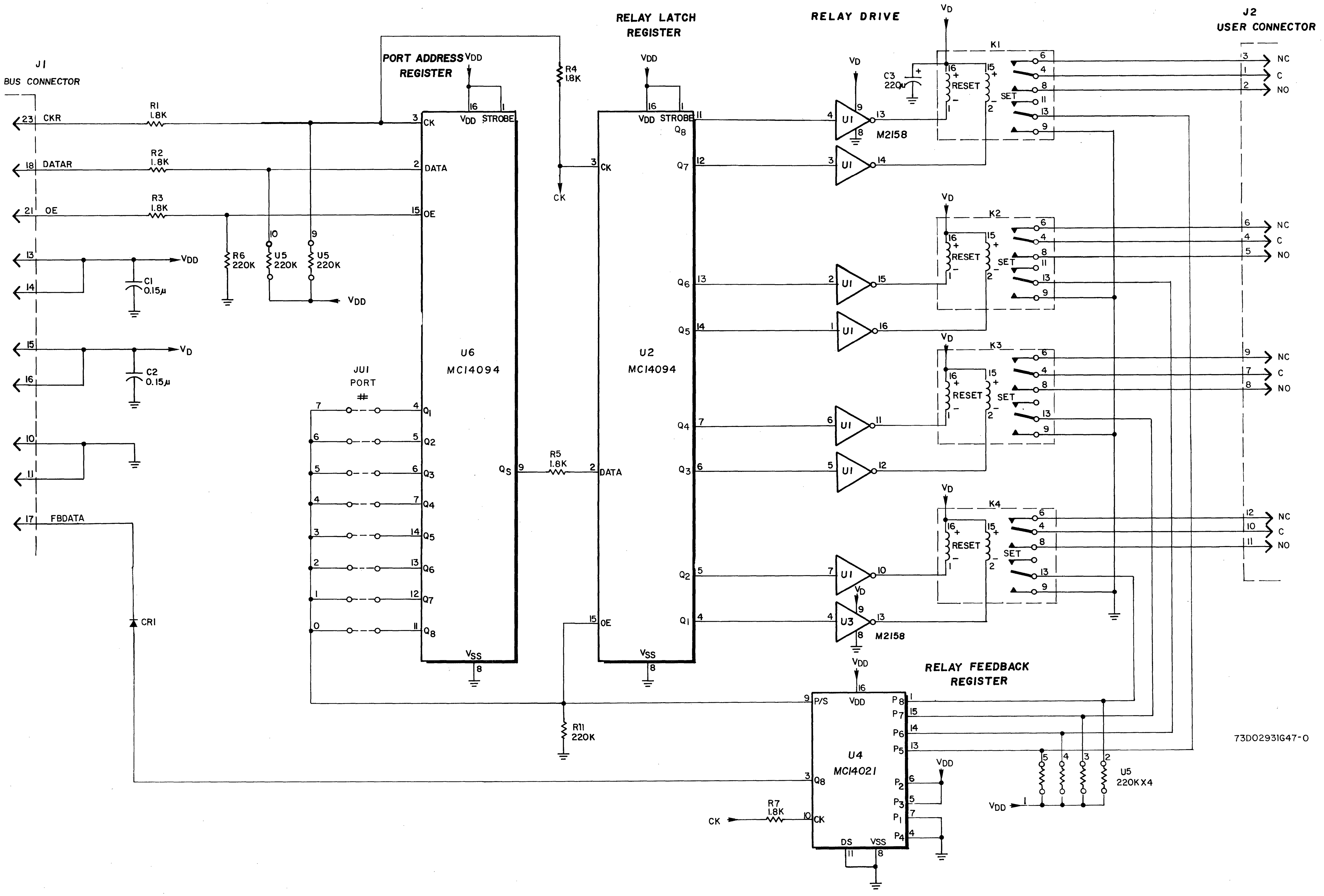
FLN4354A Four Control Outputs (CO-4)
Block Diagram
July, 1988



SHOWN FROM COMPONENT SIDE

OVERLAY	●	79B02936G35-0
COMPONENT SIDE	●	79B02936G36-0
SOLDER SIDE	●	79B02936G37-0

FLN4354A Four Control Outputs (CO-4)
Printed Circuit Board Detail
July, 1988



FLN4354A Four Control Outputs (CO-4)
Schematic Diagram
July, 1988

parts lists

FLN4354A FOUR CONTROL OUTPUT (CO-4) PL-0353-A

Reference Symbol	Motorola Part No.	Description
		Capacitors
C1,C2	21-84008H03	.15 uF 50 V
C3	23-08524G02	220 uF 35 V
		Diode
CR1	48-83654H01	HO1
		Connectors
J1	28-08044H06	bus, 26 pins
J2	28-08508G04	user, 14 pins
		Jumper
JU1	28-08522G03	plug header, 16 pins
		Relays
K1-4	80-02464C12	latch 2A 12V DIP 2-coil
		Resistors:
		ohms ±5% 1/4 W
R1-5	06-11009C55	1.8k
R6	06-11009D06	220k
R7	06-11009C55	1.8k
R8-10		not used
R11	06-11009D06	220k
		Integrated Circuits
U1	51-02162C79	ULQ2003R
U2	51-02581K44	MC14094
U3	51-02162C79	ULQ2003R
U4	51-02073C44	MC14021
U5	51-02599K14	resistor network
U6	51-02581K44	MC14094
		Non-referenced items
	29-02219K01	mini-jumper
	84-08943K01	printed circuit board

Note: For optimum performance, diodes and integrated circuits **must** be ordered by Motorola part numbers.

FLN5720 Main Board Hardware PL-0339-O

Reference Symbol	Motorola Part No.	Description
		Hardware
	01-02717G06	Terminal and Wire Assembly, includes:
	29-02231C07	terminal lug
	03-00129675	lock screw, 4-40x1/4, 2 used
	03-00134309	lock screw, 4-40x3/16
	03-08026H02	captive screw, 8-32x3/4 2 used
	03-08302H01	tapping screw, .138x1-1/2 2 used
	31-08509G04	terminal with socket
	54-08125H01	connector label

FLN4347A Modular Housing PL-0341-0

Reference Symbol	Motorola Part No.	Description
		Hardware
	02-02427C01	lock nut, 4-40x1x.22"
	03-08026H05	captive screw, 8-32x7/8, 2 used
	03-82210E15	captive screw, 2 used
	15-08513H01	housing base
	15-08586G01	housing cover
	15-08587G01	housing door
	22-02482C02	dowel pin
	54-02211H01	label
	54-08124H01	address label
	54-08635G01	front panel label

INTRAC 2000®
Modular Remote Terminal Unit
Four Control Outputs

68P02962G50-O

MOTOROLA

INTRAC 2000®

Modular Remote Terminal Unit
Eight Control Outputs

Instruction Manual

68P02957G25-O

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INTRAC 2000®
Modular Remote Terminal Unit
Eight Control Outputs

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Specifications vii

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3. Theory of Operation. 5
4. Maintenance 5

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FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar types of equipment. It contains all service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date are incorporated by Instruction Manual Revisions (SMR). These SMR's are added to the manuals as the engineering changes are incorporated into the equipment.

2. MODEL AND KIT IDENTIFICATION

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When ordering replacement parts or equipment information, the complete identification number should be included. This applies to all components, kits, and chassis. If the component part number is not known, the order should include the number of the chassis or kit of which it is a part, and sufficient description of the desired component to identify it.

Orders for crystals, channel elements, active filters, and reeds should be sent to the Component Product Sales & Service address listed below. Crystal and channel element orders should specify the crystal or channel element type number, crystal and carrier frequency, and the chassis model number in which the part is used.

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9980 Carroll Canyon Road, San Diego, CA 92131
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SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.

2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.

3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.

5. Use only a grounded soldering iron.

6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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68P02913G53-O

7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

WARNING

If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.

KIT BREAKDOWN

FLN1468A Eight Relay Control Outputs
FLN4358A Main Board
FLN5720A Hardware Main Board
FLN4347A Modular Housing
FLN4403A Label Kit
68P02957G25 Instruction Manual

SPECIFICATIONS

EIGHT RELAY CONTROL OUTPUTS

GENERAL

Operating Voltage	5 V dc (through the MRTU Bus) 10-15 V dc (through the MRTU Bus)
Current Consumption	0.2 mA from 5 V dc input 0.2 mA from 10-15 V dc input
Output Protection	2.5 kV (IEEE 472 Standard)
Operating Temperature	-30°C to +60°C
Relative Humidity	0-90% without condensation
Dimensions	1.6" x 8.3" x 3.7" (H x W x D) 40.64 x 210.82 x 93.98 mm
Weight	400 g (0.9 lb.)

CONTROL OUTPUT

Output Type	Relays
Number of Relays	Eight
Contact Rating	250 V ac 2 A max., 125 VA
Contact Type	Five jumper-selectable contacts with individual Common (C), Normally Closed (NC) or Normally Open (NO) Three jumper-selectable contacts with common C and individual NC or NO
Relay Mode	Programmable (in the MRTU MODULE): latched, momentary, general or common latched

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GENERAL DESCRIPTION
CO-8

1. GENERAL

The MRTU FLN1468A Control Output Module (MRTU CO-8) is an expansion unit, which is configured with the Modular Remote Terminal Unit (MRTU). It receives execute codewords from the MRTU Basic Module via the common bus physically contained in the flat cable that interconnects all the modules.

The CO-8 contains eight relays (K1a-K4a, K1b-K4b), which are grouped in two control ports (four relays for each control port). The relay operation mode is parameter set (momentary, latched, general or common latched). The control modes of the ports are programmed in the MRTU Basic Module, and may be altered by the user via the Field Configuration Program (refer to FRN1785 Field Configuration Program diskette).

The CO-8 is housed in a molded plastic housing. User connection is provided by a removable screw-type terminal board ("user connector") at the bottom of the module.

During MRTU operation the CO-8 is attached to the MRTU Basic Module. For a detailed description of MRTU operation, refer to FLN5003 Operation diskette.

1.1 POWER SOURCE

The CO-8 is powered by regulating the 5 V dc source (for CO-8 logic) and 12 V dc source (for relay drive) from the MRTU bus.

1.2 CO-8 OPERATION

The CO-8 performs the following functions:

a. Activates its relays upon reception of an execute codeword from the MRTU Basic Module.

b. Presets its latched and common latched relays and sets its momentary relays if a Communication Failure (CF) has occurred. The CF period and the relays to be reset are parameterized in the MRTU Basic Module .

c. The MRTU Basic Module resets the CO-8 relays upon power-up.

NOTE
The user determines the relay output type (NC, NO) by changing the position of relay jumpers JU1-JU8.

2. INSTALLATION

NOTE
Before connecting a module to the system via the flat cable assure that the system is disconnected from the electricity.

2.1 GENERAL

The CO-8 is installed at factory as an option of the MRTU, so there is no

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need for an installation procedure. When supplied as an add-on unit, follow the instructions below.

2.2 PRELIMINARY

Carefully inspect the CO-8 module immediately upon receipt and notify the shipper of any damage incurred in transit. The installation procedure consists of mounting the housing and making the necessary external and internal connections.

2.3 MOUNTING

Mount the CO-8 module on the mounting plate next to the other modules. Location of mounting holes is shown in Figure 2. Housing Detail. Connect the MRTU bus cable to the CO-8 bus connector.

2.4 DISASSEMBLY

To access a jumper, the CO-8 must be disassembled. Follow the directions below for proper disassembly of the CO-8 housing (refer to Figure 3).

Step 1. Loosen the two captive screws that hold the module to the mounting plate (not visible).

Step 2. Loosen the two screws on the right panel of the CO-8 housing.

Step 3. Lift the latch door located at the top of the housing.

Step 4. Disconnect the MRTU bus (not visible).

Step 5. Gently separate the two sides and lift the back out of the three slots located to the rear of the unit. The PC board is now exposed.

2.5 ELECTRICAL CONNECTIONS

2.5.1 Jumpers JU1-JU8

There are 10 jumpers on the PC board: 2 for port # selection (JU9, JU10), and 8 for relay operation (JU1-JU8).

Changing jumper setting involves delicate work on the PC board. This operation is best performed first before any connections are made to the CO-8 module.

WARNING

Touch the metal coating inside the housing before changing any jumper setting, to dissipate any static charge that might otherwise damage the CMOS integrated circuits.

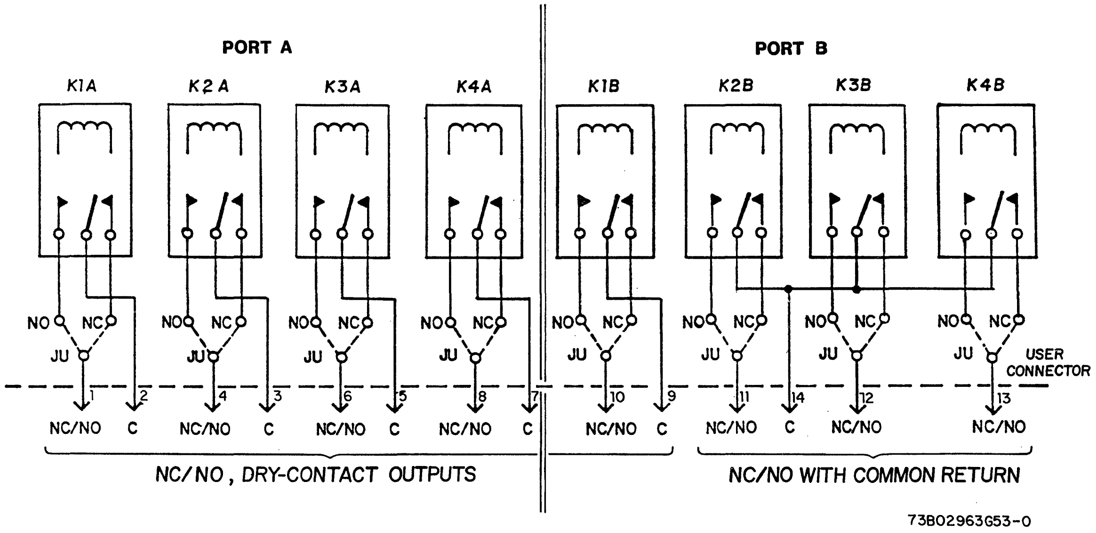
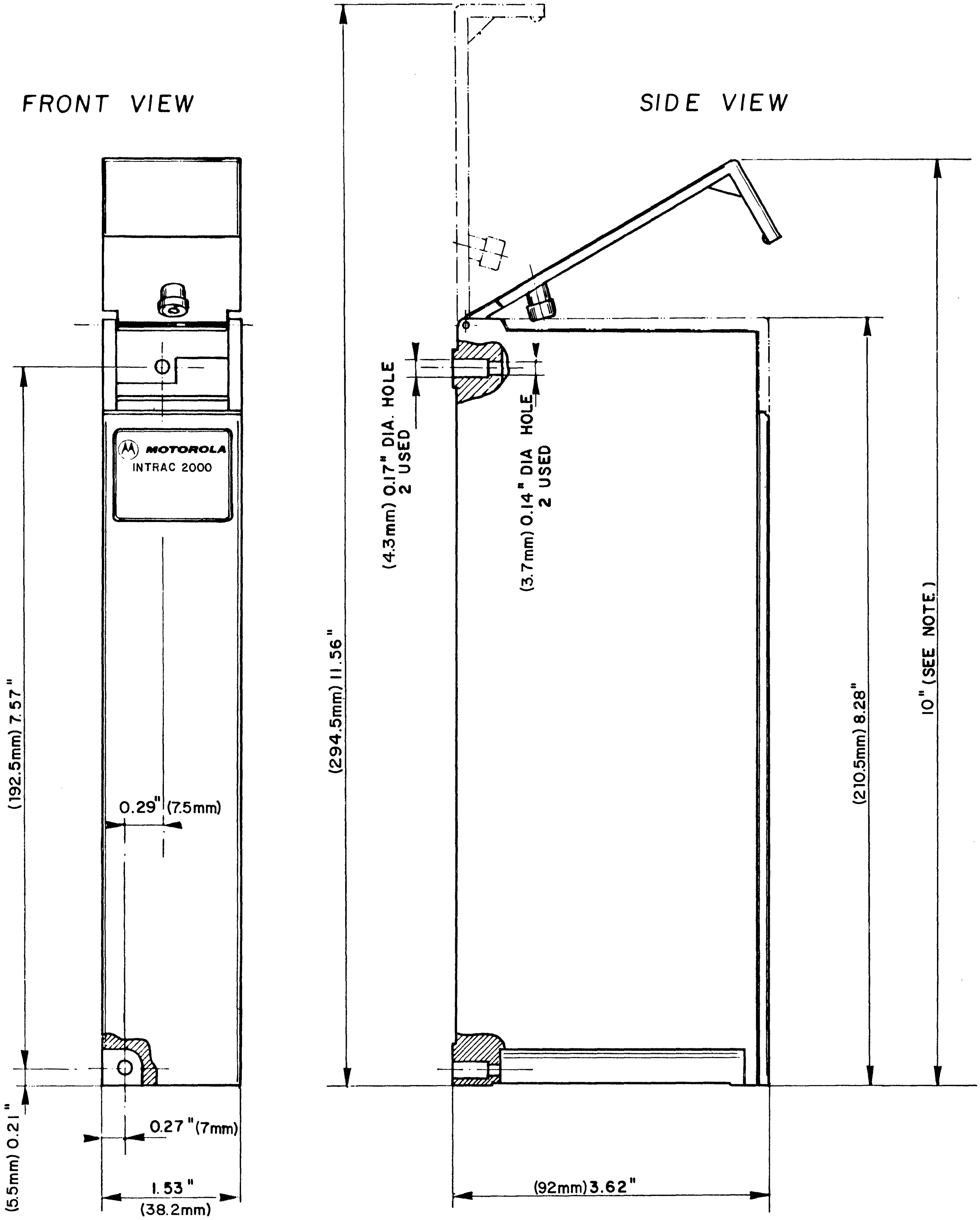


Figure 1. Control Outputs of the CO-8 Module



NOTE

MINIMUM OPENING FOR REMOVING WIRE CONNECTOR.

Figure 2. Housing Detail

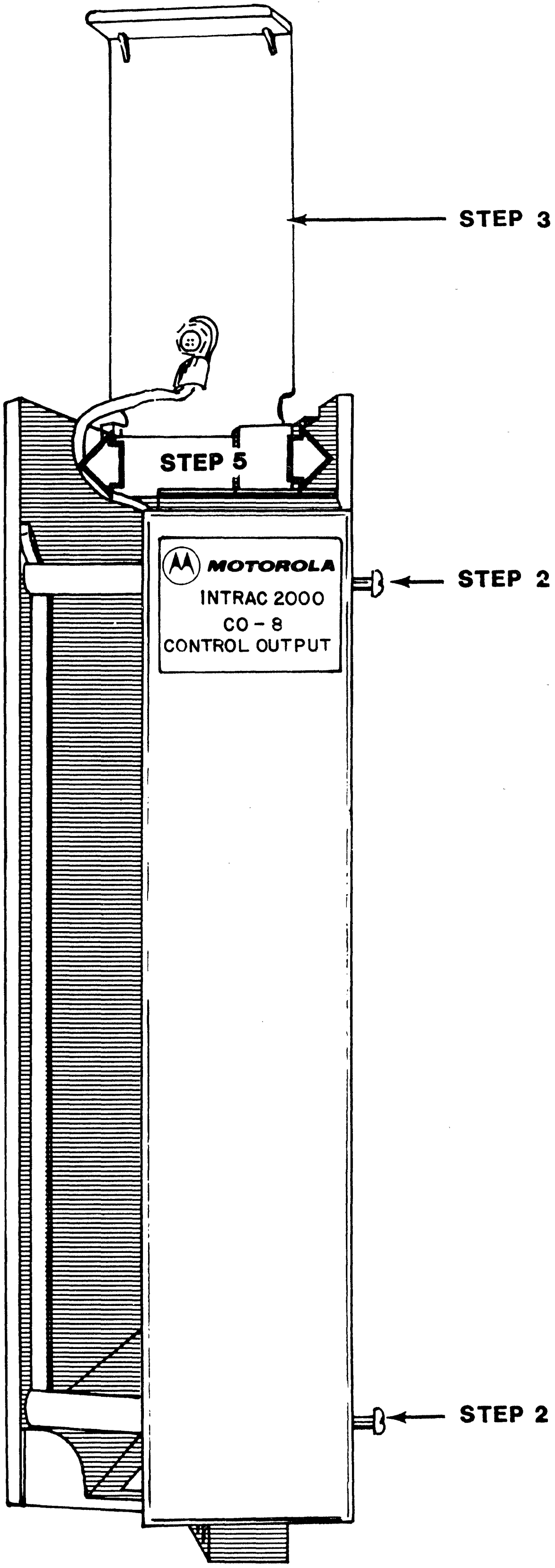


Figure 3. Disassembly

To change the jumper-selectable port # and relay contacts do as follows: locate jumpers on the PC board and insert the mini jumpers into the desired port. The port numbers and relay operation contacts are thus selected.

2.5.2 Connectors

Two connectors are mounted on the PC board to allow interconnection to other modules in the MRTU and to user devices controlled by the MRTU.

The function of each connector is listed in Table 1. Locations of connectors are shown in Figure 4. CO-8 PC Board.

3. THEORY OF OPERATION

Relay activity in the CO-8 module is similar to that of the CO-4 module. For a comprehensive understanding of the circuit description, consult the schematic diagram together with the CO-8 block diagram at the end of this chapter.

Note that the bus interface with the MRTU Basic Module consists of four signal lines, which are connected to the I/O ports of the 68HC11 microprocessor through resistors R1-3. They are:

68HC11 Ports	Bus Connector
PA0	CKR
PA1	DATAR
PA2	OE
PA3	FBDATA

Table 1. Connector Functions

CONNECTOR	FUNCTION	DESCRIPTION
J1	User connector	Connects the Control Output module to user devices; contains 14 pins (see schematic diagram).
J2	Bus connector	Connects to the MRTU bus; contains 26 contacts (see schematic diagram).

4. MAINTENANCE

Failure diagnostic originates in the MRTU Basic Module. The MRTU Basic Module includes 8 LEDs connected to a test pushbutton.

During normal operation the LEDs will display the local inputs state. Pressing the test pushbutton will light the LEDs for 1 second and then the current error LEDs will light up.

LED #4 indicates a relay back-indication failure, which signifies that an output relay is disabled. In order to identify the disabled relay do as follows:

Step 1. Disconnect all control output modules in the system.

Step 2. Connect one control output module at a time and send a message via each relay to verify which relay is disabled.

Step 3. Press the test pushbutton on the MRTU Basic Module after each message to verify that the relay is working properly.

Step 4. When faulty relay is identified change the CO-4 or CO-8 module with the faulty relay.

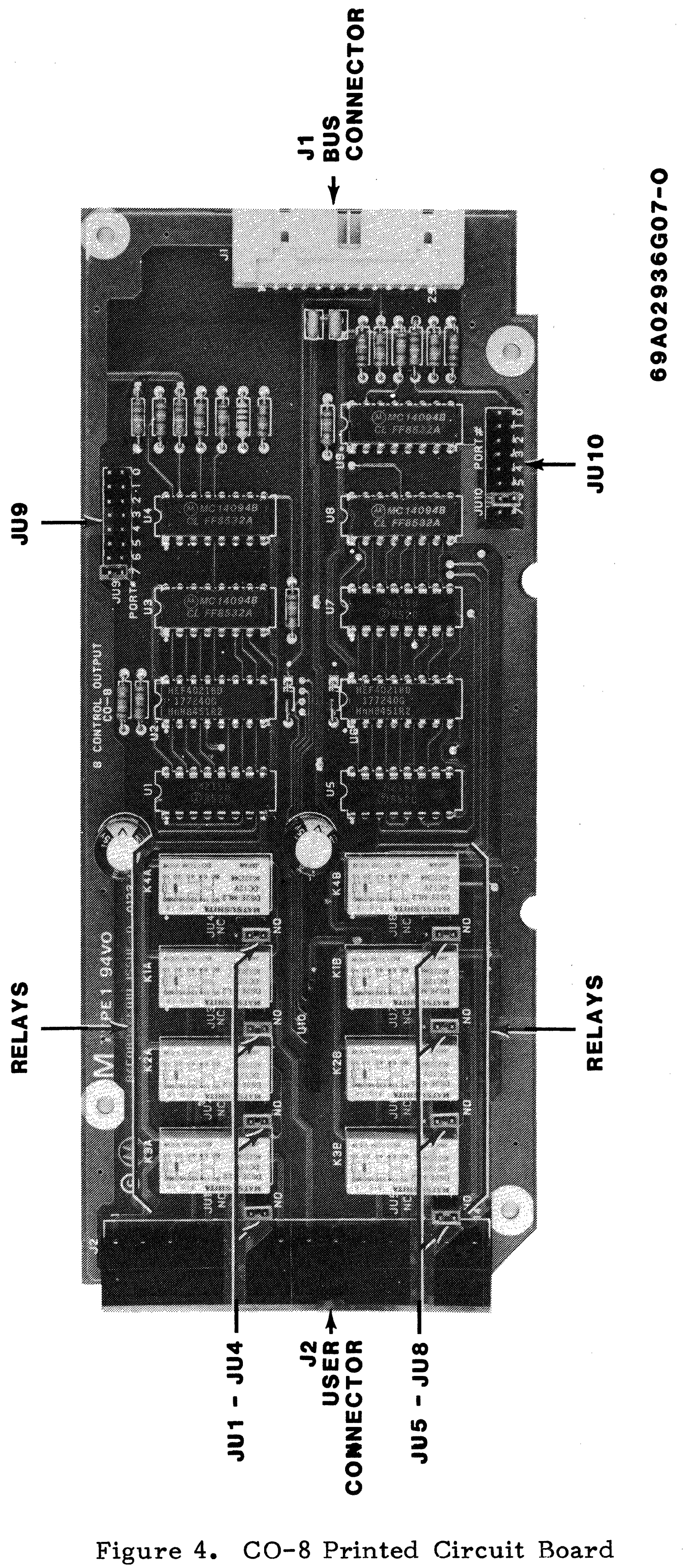
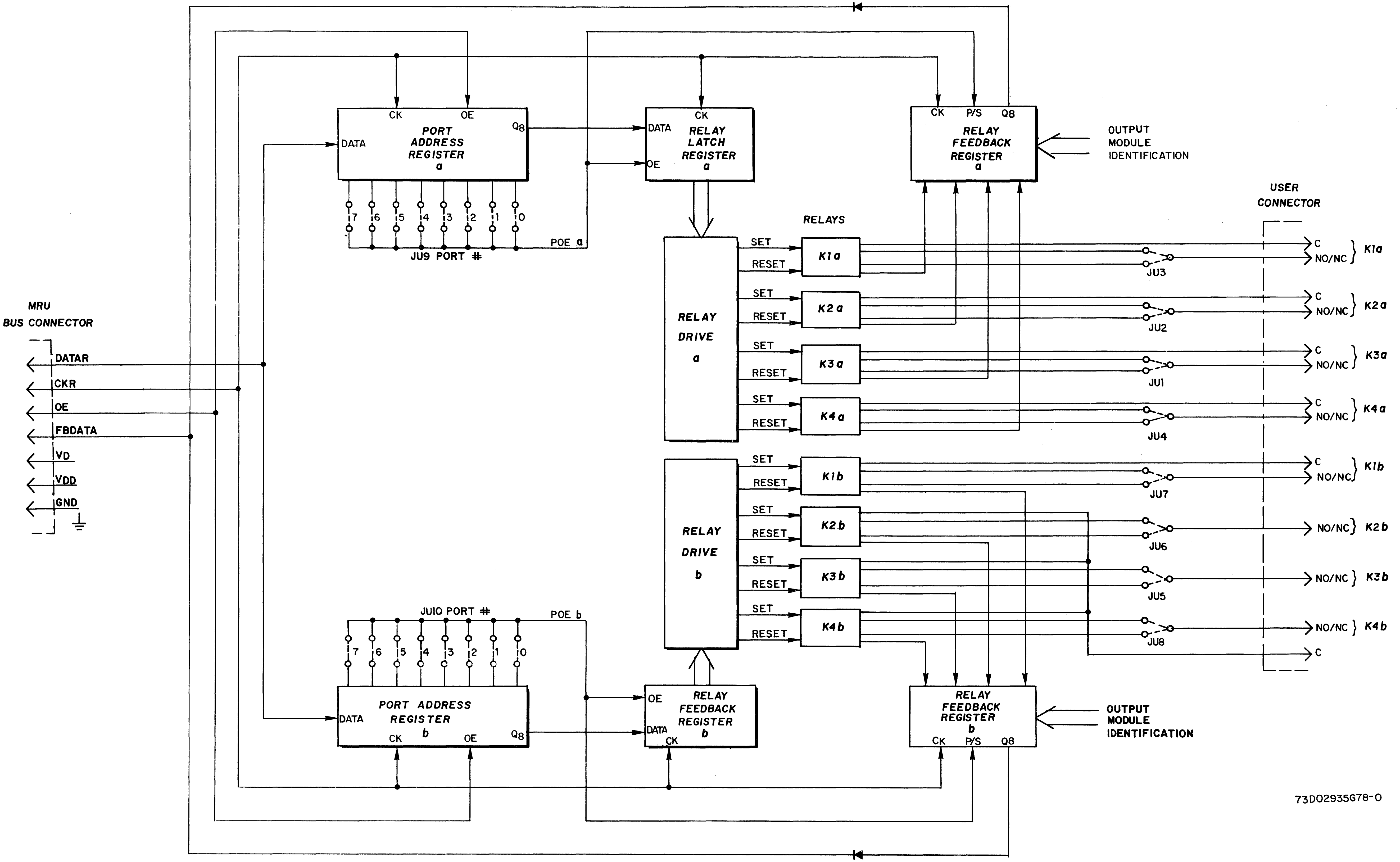
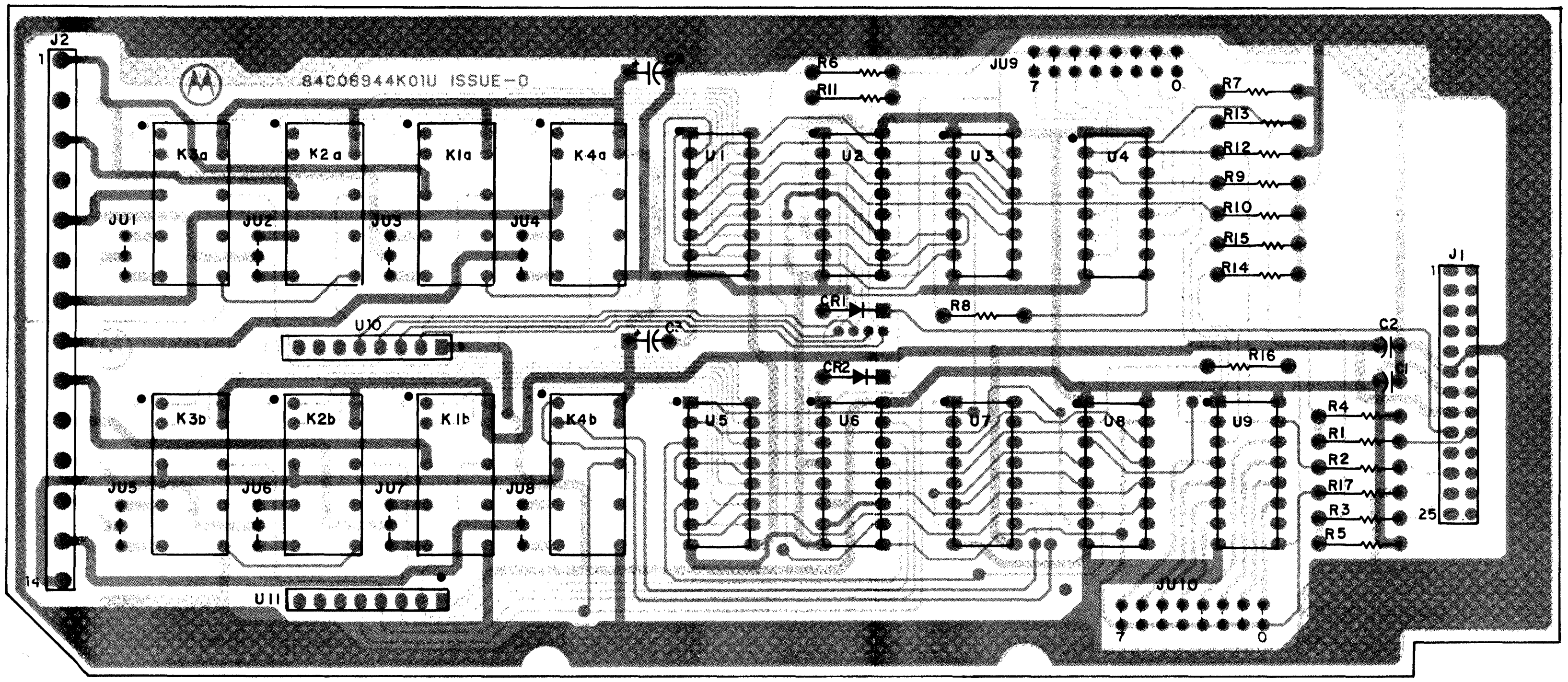


Figure 4. CO-8 Printed Circuit Board



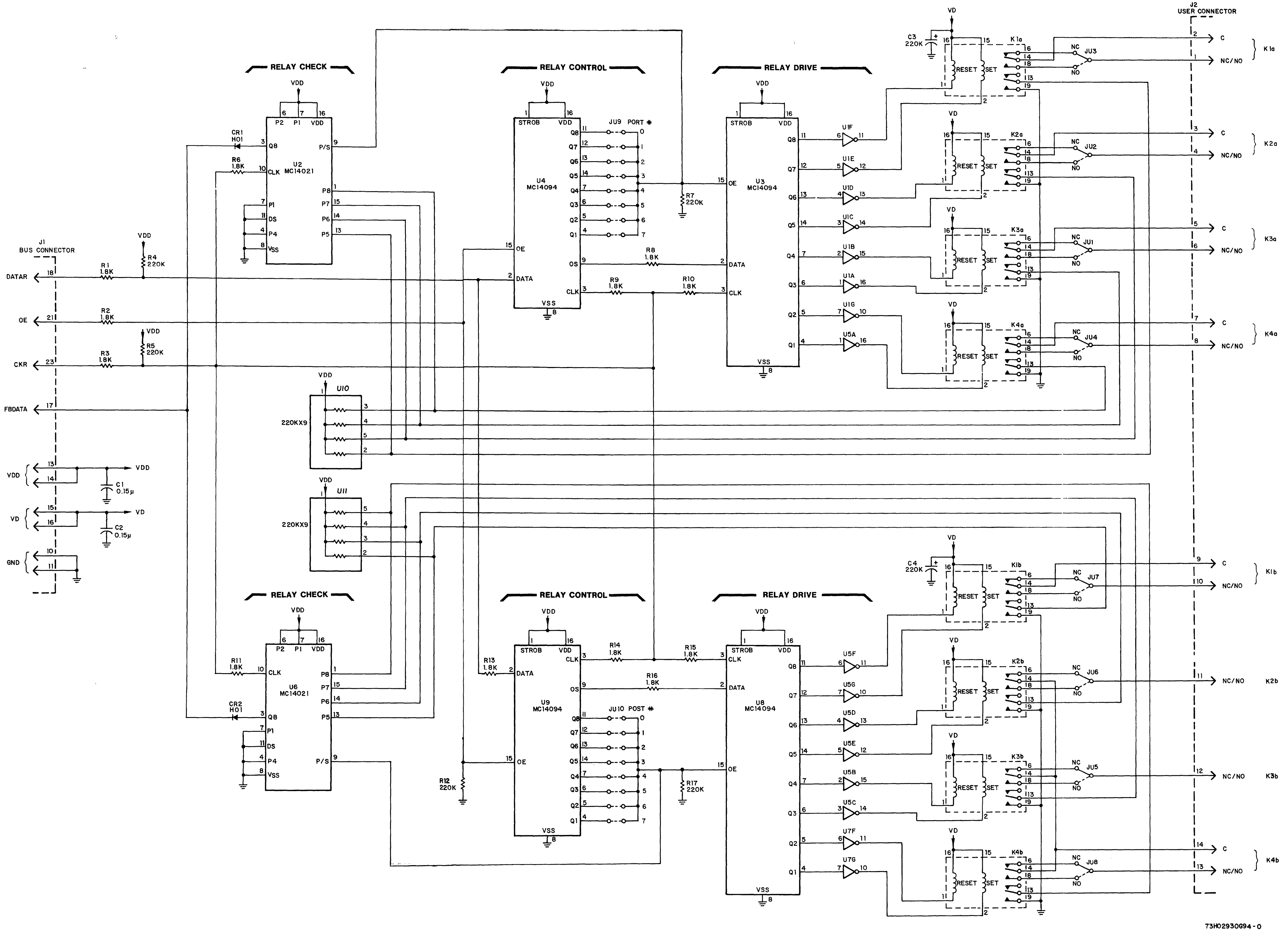
FLN4358A Eight Control Outputs (CO-8)
Block Diagram
July, 1988



SHOWN FROM COMPONENT SIDE

OVERLAY	●	79B02936G32-0
COMPONENT SIDE	●	79B02936G33-0
SOLDER SIDE	●	79B02936G34-0

FLN4358A Eight Control Outputs (CO-8)
Printed Circuit Board Detail
July, 1988



FLN4358A Eight Control Outputs (CO-8)
Schematic Diagram
July, 1988

parts lists

FLN4358A EIGHT CONTROL OUTPUT (CO-8) PL-0354-A

Reference Symbol	Motorola Part No.	Description
		Capacitors
C1,C2	21-84008H03	.15 uF 50 V
C3,C4	23-84665F06	220 nF 25 V
		Diodes
CR1,CR2	48-83654H01	HOI
		Connectors
J1	28-08044H06	bus, 26 pins
J2	28-08508G04	user, 14 pins
		Jumpers
JU1-JU8	28-82622L01	plug, 3 pins, 8 used
JU9,JU10	28-08522G03	plug header; 16 pins
		Relays
K1-K8 (K1a,K1b, K2a,K2b, K3a,K3b, K4a,K4b)	80-02464C12	latch; 2A 12V DIP 2-coil
		Resistors: ohms ±5% 1/4 W
R1-R3	06-11009C55	1.8k
R4,R5	06-11009D06	220k
R6	06-11009C55	1.8k
R7	06-11009D06	220k
R8-R11	06-11009C55	1.8k
R12	06-11009D06	220k
R13-R16	06-11009C55	1.8k
R17	06-11009D06	220k
		Integrated circuits
U1	51-02162C79	ULQ2003R
U2	51-02073C44	CMOS,MC14021
U3,U4	51-02581K44	CMOS,MC14094
U5	51-02162C79	ULQ2003R
U6	51-02073C44	CMOS,MC14021
U7	51-02162C79	ULQ2003R
U8,U9	51-02581K44	CMOS,MC14094
U10,U11	51-02599K13	resistor network; 220k x 8
		Non-referenced items
	29-02219K01	mini-jumper, 10 used
	84-08944K01	printed circuit board

Note: For optimum performance, diodes and integrated circuits **must** be ordered by Motorola part numbers.

FLN5720 Main Board Hardware PL-0339-O

Reference Symbol	Motorola Part No.	Description
		Hardware
	01-02717G06	Terminal and Wire Assembly, includes:
	29-02231C07	terminal lug
	03-00129675	lock screw, 4-40x1/4, 2 used
	03-00134309	lock screw, 4-40x3/16
	03-08026H02	captive screw, 8-32x3/4 2 used
	03-08302H01	tapping screw,.138x1-1/2 2 used
	31-08509G04	terminal with socket
	54-08125H01	connector label

FLN4347A Modular Housing PL-0341-0

Reference Symbol	Motorola Part No.	Description
		Hardware
	02-02427C01	lock nut, 4-40x1x.22"
	03-08026H05	captive screw,8-32x7/8, 2 used
	03-82210E15	captive screw, 2 used
	15-08513H01	housing base
	15-08586G01	housing cover
	15-08587G01	housing door
	22-02482C02	dowel pin
	54-02211H01	label
	54-08124H01	address label
	54-08635G01	front panel label

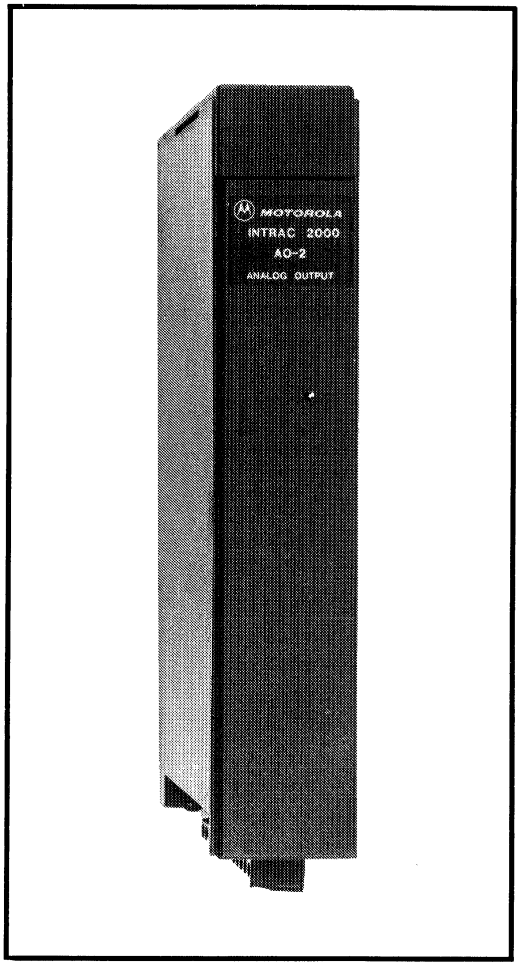
INTRAC 2000
Modular Remote Terminal Unit
Eight Control Outputs

68P02957G25-O

MOTOROLA

INTRAC 2000™

Modular Remote Unit
Analog Output



Instruction Manual

68P02937G55-O

COMMERCIAL WARRANTY
(STANDARD)

Motorola radio communications products are warranted to be free from defects in material and workmanship for a period of ONE (1) YEAR, (except for crystals and channel elements, which are warranted for a period of ten (10) years) from the date of shipment. Parts, including crystals and channel elements, will be replaced free of charge for the full warranty period, but the labor to replace defective parts will only be provided for One Hundred-Twenty (120) days from the date of shipment. Thereafter, purchaser must pay for the labor involved in repairing the product or replacing the parts at the prevailing rates together with any transportation charges to or from the place where warranty service is provided. This express warranty is extended by Motorola Communications and Electronics, Inc., 1301 Algonquin Road, Schaumburg, Illinois 60196, to the original purchaser only, and only to those purchasing for purpose of leasing or solely for commercial, industrial, or governmental use.

THIS WARRANTY IS GIVEN IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, WHICH ARE SPECIFICALLY EXCLUDED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL MOTOROLA BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW.

In the event of a defect, malfunction or failure to conform to specification established by SELLER, or if appropriate, to specifications accepted by Seller in writing, during the period shown, Motorola, at its option, will either repair or replace the product or refund the purchase price thereof, and such action on the part of Motorola shall be the full extent of Motorola's liability hereunder.

This warranty is void if:

a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage; and/or
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

The warranty extends only to individual products; batteries are excluded. Because each radio system is unique, Motorola disclaims liability for range, coverage, or operation of the system as a whole under this warranty except by a separate written agreement signed by an officer of Motorola.

LICENSED PROGRAMS: Motorola software provided in connection with this order is warranted to be free from reproducible defects for a period on ONE (1) YEAR. All material and labor to repair any such defects will be provided free of charge for the full warranty period, and SUBJECT TO THE DISCLAIMER IN BOLDFACE TYPE.

Non-Motorola manufactured products are excluded from this warranty, but are subject to the warranty provided by their manufacturers, a copy of which will be supplied to you on specific written request.

In order to obtain performance of this warranty, purchasers must contact their Motorola sales person or Motorola at the address first above shown, attention Quality Assurance Department.

This warranty applies only within the United States.

EPS-30831-O

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EPS-34440-A

MOTOROLA INC.
Communications
Sector

INTRAC 2000™
Modular Remote Unit
Analog Output

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Communications Sector

FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar equipment. The information it contains is current as of the printing date. Subsequent engineering changes are described in supplementary Instruction Manual Revisions (IMRs) issued as needed. The applicable schematic diagram is updated and the changes are described in a revision column printed either on the diagram or next to the corresponding parts list.

2. SERVICE

The Motorola National Service Organization offers one of the finest nationwide installation and maintenance programs available to communications equipment users. This organization comprises approximately 900 Motorola Service Stations located throughout the United States. Each Service Station is independently owned and operated, is staffed by one or more trained, FCC-licensed technicians, and is specially selected and authorized by Motorola.

The administrative staff of the National Service Organization consists of national, area and district service managers, and district representatives, all of whom are Motorola employees. Their objective is continually to improve the service to Motorola customers.

Motorola maintenance is available either on a time and material basis, or by means of a service contract. To obtain a service contract, contact your Motorola Service Representative, or write to:

National Service Manager
Motorola Communications and Electronics Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

3. MODEL AND KIT IDENTIFICATION

Every Motorola product is specifically identified by an overall model number printed on the nameplate. In addition, the assemblies and kits comprising the product usually have kit model numbers stamped on them.

4. REPLACEMENT PARTS ORDERING

Motorola maintains a **factory parts center** and several **area parts centers** located throughout the United States. These facilities are equipped to process parts orders, identify part numbers, and otherwise assist in the maintenance and repair of Motorola Communications Group products. The addresses of these parts centers are listed on the following page.

Orders for crystals, channel elements, active filters, PROMs, code plugs, and resonant reeds should be

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sent directly to the **factory parts center.** Orders for all other parts and for instruction manuals should be sent to the nearest **area parts center.**

All orders for replacement parts or equipment information should include the complete identification number. This requirement applies to all components, kits and chassis. If the component part number is not known, the order should include the number of the chassis or kit which uses it, and a description of the desired component sufficient to identify it.

Orders for crystals and channel elements should specify the crystal or channel element type number, crystal and carrier frequencies, and the model number of the chassis using the part.

Orders for active filters, PROMs, code plugs, and "Vibrasender" and "Vibrasponder" resonant reeds, should specify type number and frequency, and should identify the owner/operator of the communications system utilizing these items.

5. ADDRESSES

5.1 AREA PARTS CENTERS

5.1.1 U.S. Orders

Western Area Parts
1170 Chess Drive, Foster City
San Mateo, California 94404
Telephone: 415-349-3111
TWX: 910-375-3877

Midwest Area Parts
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-7322
TWX: 910-693-0869

Mid-Atlantic Area Parts
7230 Parkway Drive
Hanover, Maryland 20176
Telephone: 301-796-8600
TWX: 710-862-1941

East Central Area Parts
12995 Snow Road
Parma, Ohio 44130
Telephone: 216-267-2210
TWX: 810-421-8845

Eastern Area Parts
85 Harristown Road
Glen Rock, New Jersey 07452
Telephones: 201-447-4000
TWX: 710-988-5602

Pacific Southwestern Area Parts
P.O. Box 85036
San Diego, California 92138
Telephone: 714-578-2222
TWX: 910-335-1634

Gulf States Area Parts
8550 Katy Freeway, Suite 128
Houston, Texas 77024
Telephone: 713-932-8955

Southwestern Area Parts
P.O. Box 34290
3320 Belt Line Road
Dallas, Texas 75234
Telephone: 214-241-2151
TWX: 910-860-5505

Southeastern Area Parts
P.O. Box 368
Decatur, Georgia 30031
Telephone: 504-981-9800
TWX: 810-766-0876

5.1.2 Canadian Orders

Motorola Ltd.
National Parts Department
3125 Steeles Avenue
E. Willowdale, Ontario M2H 2H6
Telephone: 416-499-1441
TWX: 610-492-2713
Telex: 065-25191

5.1.3 All Other Countries

Motorola Inc., or
Motorola Americas, Inc.
International Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
U.S.A.
Telephone: 312-576-6492
TWX: 910-693-0869
Telex: 722443 or 722424
Cable: MOTOL PARTS

5.2 FACTORY PARTS CENTER

5.2.1 Mail Orders

Motorola, Inc.
Component Products Sales and Service
P.O. Box 66191
O'Hare International Airport
Chicago, Illinois 60666

5.2.2 Other Correspondence

Motorola, Inc.
Component Products Sales and Service
2553 N. Edgington Street
Franklin Park, Illinois 60131

5.3 GENERAL OFFICES

Motorola Communications and Electronics Inc.
Communications Group Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-3900

KIT BREAKDOWN

FLN1463A Analog Output Module (AO-2)

FLN4344A	Main Board
FLN4347A	Modular Housing
FLN4401A	Label Kit
FLN5720A	Hardware Kit

PERFORMANCE SPECIFICATIONS

GENERAL

Input Power	11-15 V dc 14 mA average (from VD on the MRU bus) 5 V dc regulated 4 mA max (VDD on the MRU bus.
External DC supply	15-28 V dc 45 mA max (depending on (for load only) the external load)
Operating Temperature Range	-30 °C to +60 °C
Relative Humidity	0-95% (non condensing)
Housing	Thermo-plastic module
Weight	0.157 lbs. (0.350 kg)
Dimensions	1.6" x 8.3" x 3.7" (h x w x d) 40.64 x 210.82 x 93.98 mm

ANALOG

Analog Channels	2 each with voltage and current outputs (simultaneously)
Voltage output/possible ranges	±1 V, 0-1 V 1 K Ohm min load ±5 V, 0-5 V 5 K Ohm min load
Current Output	4-20 mA 300 Ohm max load (without external dc supply) 4-20 mA 1K Ohm max load (with external 28 V dc supply)
Analog Accuracy	±0.1% @ 25 °C, ±50 ppm/°C Vout ±100 ppm/°C Iout
Resolution	10 bits
Linearity	±0.3% Vout ±0.5% Iout
Time Response	20 msec max to 90% of full scale (FS)
Limit Accuracy	±0.1% of FS with 2.5% hysteresis adjustable high and low
Limits Outputs	Open collector, active low, 250 mA, 28V dc maximum ratings
Surge Protection	Analog outputs and limits: ANSI/IEEE C37.90-1978 (IEEE 472-1974) 3 KV Capacitor discharge 600 V 25uF 15-28 V dc external input: IEEE 587-1980 6 KV Capacitor discharge 600 V 25uF

MOTOROLA INC.
Communications Sector

SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.

2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.

3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.

5. Use only a grounded soldering iron.

6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

WARNING

If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.

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Communications
Sector

GENERAL DESCRIPTION

1. GENERAL

The Analog Output Module (AO-2) is an expansion unit configured with the Modular Remote Unit (MRU).

Each AO-2 module provides two separate analog channels (up to four AO-2 modules can be attached to the MRU). All communications between the AO-2 modules and the MRU are carried out via a common "bus" physically contained in the flat cable that interconnects all the MRU modules.

The AO-2 module is housed in a molded plastic housing. User-connection is provided by a removable screw-type terminal board ("user connector") at the bottom of the module.

The Decoder module of the MRU is responsible for the communication of digital messages from the central station (or another MRU) to the AO-2 module. The AO-2 module converts the digital messages into analog voltage and current.

2. FUNCTIONAL DESCRIPTION

2.1 ANALOG OUTPUTS

Each analog channel contains a digital-to-analog (D/A) converter which converts a ten-bit digital value (received from the Decoder) to an analog output.

The ranges of the analog output are: ±1 V, 0 to 1 V ±5 V, 0 to 5 V (jumper selectable), and a separate current output in the range of 4-20 mA (in correlation with ±1 V).

2.2 LIMITS

In addition to the analog output, each analog channel provides adjustable high and low limits (two discrete outputs), which may be used for various purposes, e.g., activate an alarm, report to the central (as a status input), etc.

The limits cover the entire analog range. They close a contact to indicate analog values that are high/low with respect to the high and low limits.

2.3 PRESET VALUES

The preset value defines the first analog value sent from the Decoder to the AO-2 module (before a command is sent from the central).

One out of two preset values is delivered by the Decoder upon power-up of the MRU. The preset value is DIP switch selectable in the AO-2 module and represented by the digital values -500 and 0. (The specific analog output values depend on the jumpers' configuration.)

NOTE

> The preset value is delivered after power-up of the Decoder module. Prior to this communication an internal reset

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is executed in the AO-2 module, which forces a digital value of -512 as the first digital value to be converted. Hence, connecting an AO-2 module only to a supply of 5 V and 12 V will produce analog values represented by -512.

2.4 POWER SUPPLY

The AO-2 module is provided with 12 V dc and 5 V dc by the MRU bus. In addition, the module may be connected to an external power source for analog current applications where the loop resistance is up to 1 K Ohm. Another possibility (jumper selectable) is to use the Power Fail indication on the MRU bus as an input to the AO-2 module that disconnects the module from the 12 V power supply when ac power fail occurs (JU7 b). This enables longer back-up time for the MRU battery.

NOTE

During ac power fail digital data stays stored in the internal memory of the AO-2 module, so that upon ac power-up the analog output will be updated according to the last transmitted data. (Note that Power Fail is by default **not active.**)

2.5 ADDRESSING

The AO-2 module includes two individual channels. Each channel can be assigned to one of eight ports (0-7) and one of eight groups (A-H) in any combination, (e.g., channel 1 can be port #3 and group address B).

Output operations are controlled by the Decoder which communicates with the output modules via the MRU bus.

The communication is bi-directional, i.e., the Decoder loads the data into the output modules, but can also read data from the output modules.

The Decoder outputs are organized as eight output ports (control ports and analog ports). A control port provides four control (relay) outputs; an analog port provides one analog output.

A port number (0-7) is assigned to each port by means of a jumper located in the specific channel in the AO-2 module and identifies the output channel and the group address.

NOTE

Analog ports must be assigned port numbers which are not used for control ports. The used analog ports are identified automatically by the Decoder.

A specific port number can be assigned to only one analog channel.

The Decoder is capable of addressing up to eight analog channels; however, when all eight channels are in use there are two limitations:

a. "Reception mode" parameter (which means, rejection upon receiving INTRAC word with bit 15=1) is disabled.

b. No interrogation can be performed.

Refer to the 68P02928G55 Decoder instruction manual for further details.

The central station assigns a group address to the message it sends to the Decoder, the Decoder then assigns a port number to which it will deliver the specific message. The conversion of analog groups to port numbers is performed via DIP switches and jumpers located on the AO-2 module printed circuit board.

Digital information is transferred from the AO-2 module to the Decoder through the MRU bus, thus enabling the Decoder to read the parameters of the AO-2 module (port, group, preset value). This feature eliminates the need to change parameters inside the Decoder when adding AO-2 modules to the MRU.

INSTALLATION

1. PRELIMINARY

Carefully inspect the AO-2 module immediately upon receipt and notify the shipper of any damage incurred in transit. The installation procedure consists of mounting the housing and making the necessary external and internal electrical connections.

2. MOUNTING

Mount the AO-2 module next to the other MRU modules with the two captive screws (included with the module) then connect the MRU bus flat cable to the bus user connector of the AO-2 module.

3. DISASSEMBLY

To access either jumpers or switches the AO-2 module must be disassembled. Follow the directions below for proper disassembly of the AO-2 module housing (refer to Figure 2. Disassembly).

Step 1. Lift the latch door located at the top of the housing.

Step 2. Disconnect the MRU bus flat cable.

Step 3. Loosen the two captive screws which hold the module to the mounting plate (not visible).

Step 4. Loosen the two screws on the right panel of the AO-2 module housing.

Step 5. Assure that the latch door is open.

Step 6. Gently separate the two sides, exposing the printed circuit board (PCB).

4. JUMPERS

Refer to Figure 3, Printed Circuit Board for jumper location, and to Table 1 for jumper assignment.

Changing jumper settings involves delicate work on the PCB. This operation is best performed before any connections are made to the AO-2 module.

After changing one of the jumpers (1-4) that affect the range of output voltage and current, the module must be adjusted. Refer to the Maintenance section (in this manual), paragraph 7 Adjustments.

> WARNING
> Touch the metal coating inside the housing before changing any jumper setting, to dissipate any static charge that might otherwise damage the CMOS integrated circuits.

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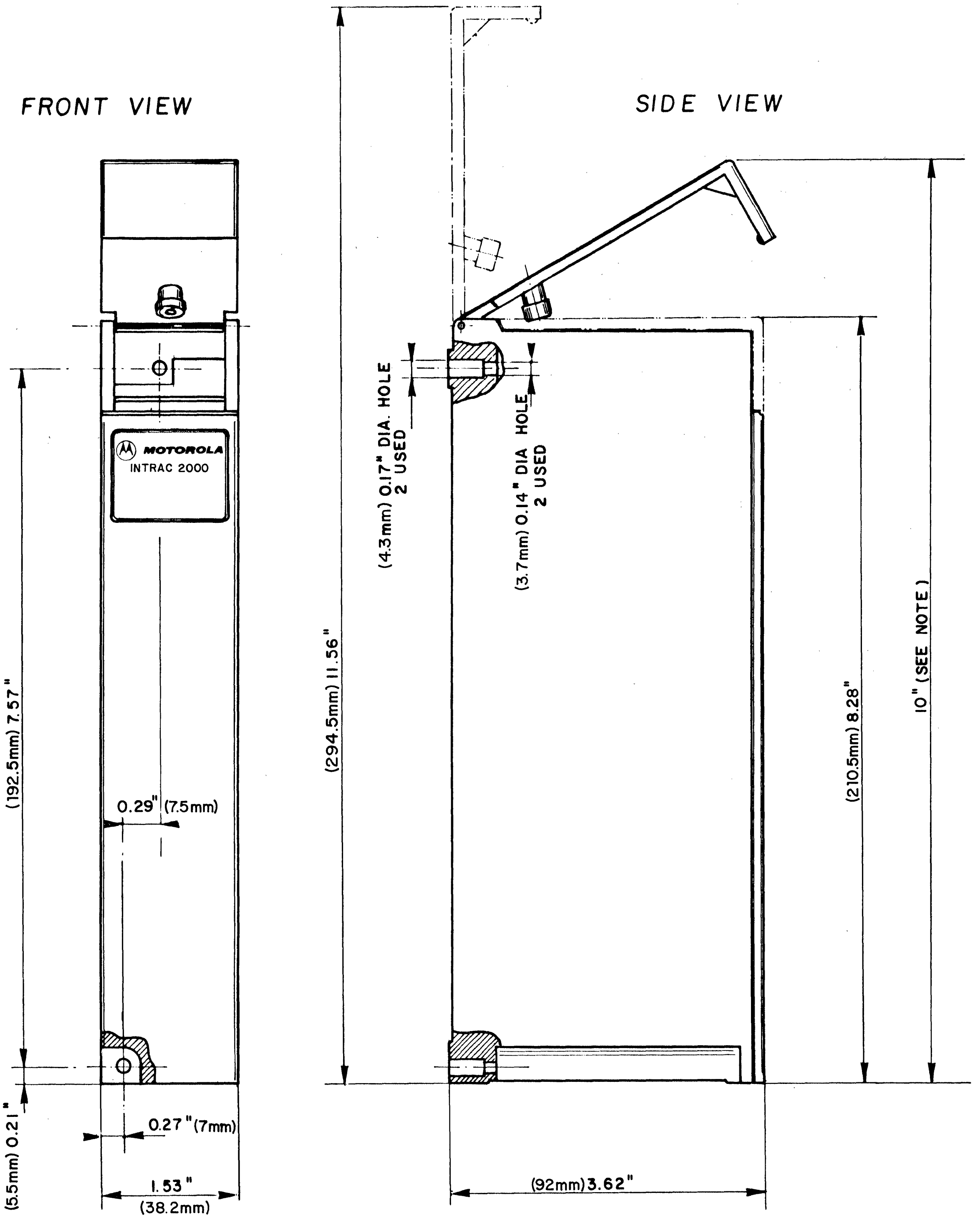

NOTE

MINIMUM OPENING FOR REMOVING
WIRE CONNECTOR.

73C02936G40-0

Figure 1. Housing Detail

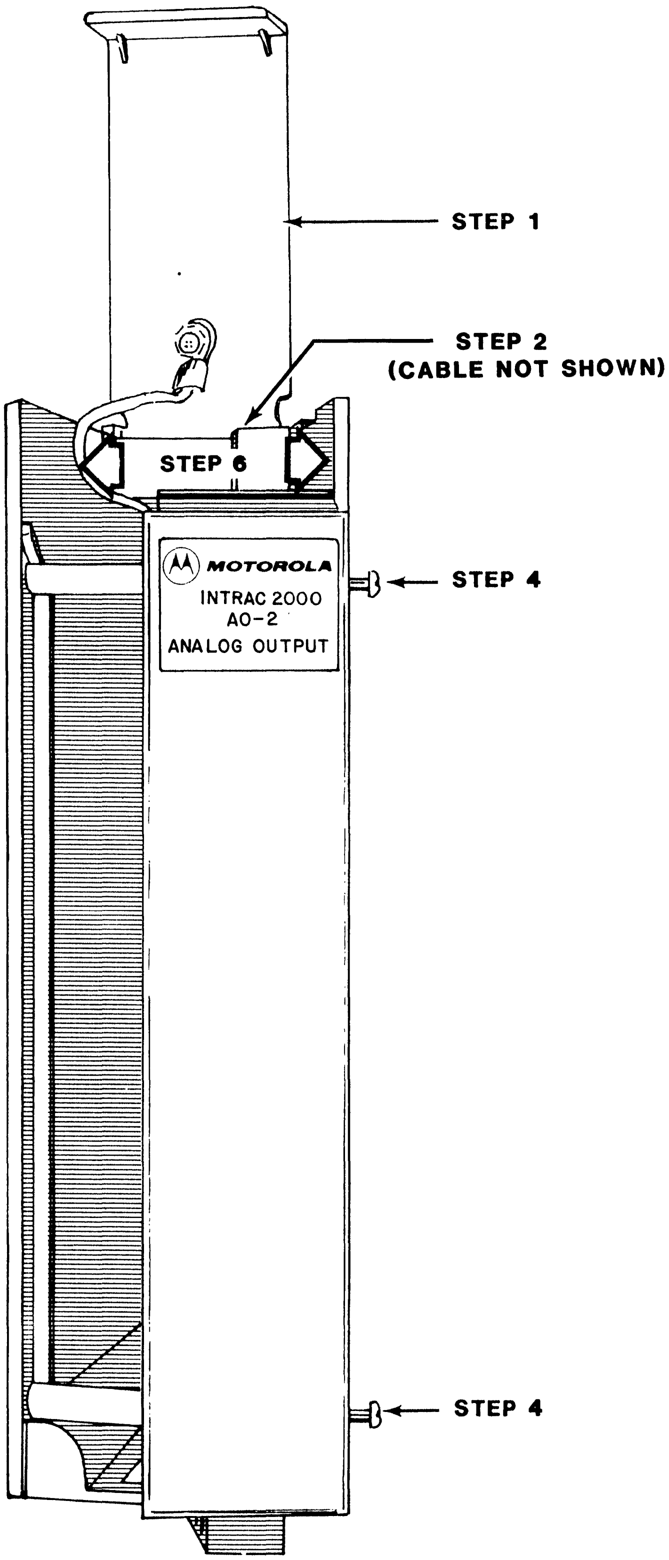

Figure 2. Disassembly

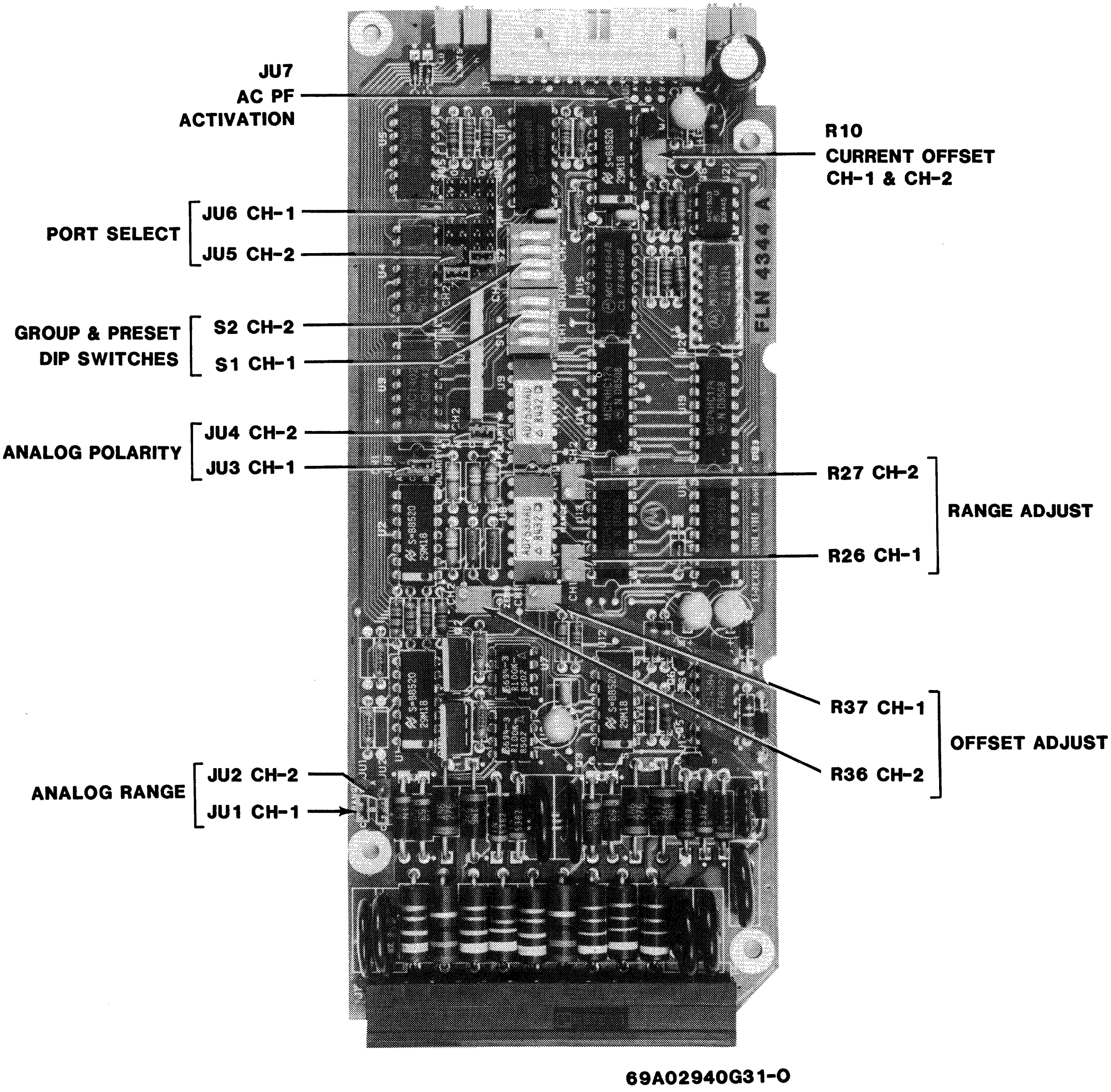

Figure 3. Printed Circuit Board

Table 1. Jumpers and Switches

Switches/Jumpers	Position	Description
S1-1 (Preset value)	Closed* Open	Channel 1 Preset to 0 upon power-up Preset to -500 upon power-up
S1-2(MSB) S1-3 (Group) S1-4	Select Group A-H**	Channel 1 Select the group (i.e., all closed for group A etc.) S1-4 is the LSB
S2-1 (Preset Value)	Closed* Open	Channel 2 Preset to 0 upon power-up Preset to -500 upon power-up
S2-2(MSB) S2-3 (Group) S2-4	Select Group A-H**	Channel 2 Select the group (i.e., all closed for group A etc.) S2-4 is the LSB
JU1	c-a c-b*	Channel 1 5 V range 1 V range
JU2	c-a c-b*	Channel 2 5 V range 1 V range
JU3	c-a c-b*	Channel 1 Unipolar output 0-1 or 0-5 Bipolar output ±1 or ±5
JU4	c-a c-b*	Channel 2 Unipolar output 0-1 or 0-5 Bipolar output ±1 or ±5
JU5 (Port select)	Select port # 0-7**	Channel 1 Select port # (0 for port #0 etc.)
JU6 (Port select)	Select port # 0-7**	Channel 2 Select port # (0 for port #0 etc.)
JU7	c-a c-b*	Power save during ac power fail No such mode

* Factory Default. **Default set at factory according to module position.

Table 2. Analog Outputs

Analog Output		Preset Value S1-1 (S2-1)				Jumpers	
Voltage	Current	Open (-500)		Closed (0)		JU1 (JU2) Range	JU3 (JU4) Polarity
±1 V	4-20 mA	-1 V	4 mA	0 V	12 mA	b	b
0-1 V	--	0 V	--	0.5 V	--	b	a
±5 V	--	-5 V	--	0 V	--	a	b
0-5 V	--	0 V	--	2.5 V	--	a	a

-- not used

Table 3. Group Selection

GROUP CHANNEL 1	S1-2	S1-3	S1-4
GROUP CHANNEL 2	S2-2	S2-3	S2-4
A	0	0	0
B	0	0	1
C	0	1	0
D	0	1	1
E	1	0	0
F	1	0	1
G	1	1	0
H	1	1	1

0 = Closed
1 = Open

5. SWITCHES

The switches on the AO-2 module enable the selection of the preset value and group address for each analog channel. Refer to Table 3 Group Selection.

6. EXTERNAL CONNECTIONS

6.1 GENERAL

All electrical cables should be consistent with the mounting location environment and should conform to applicable electrical codes.

6.2 BUS CONNECTION

The connection between the AO-2 module and MRU Decoder is accomplished via a 26-pin flat cable connected to the bus connector J2 on the AO-2 module. In order to insert the cable connector correctly into J2, the user must match the key on the male and female connectors.

6.3 USER CONNECTIONS

All user connections are through user connector (J1). The connections are (related to GND) according to the following table:

Table 4. User Connections

J1 Pin	Function
1	Voltage output, Channel 1
2	GND
3	Current output, Channel 1
4	High limit, Channel 1
5	GND
6	Low limit, Channel 1
7	Voltage output, Channel 2
8	GND
9	Current output, Channel 2
10	High limit, Channel 2
11	GND
12	Low limit, Channel 2
13	15-28 V dc external supply
14	GND

6.4 VOLTAGE OUTPUT

The voltage output is short circuit protected. In order to match the voltage output to the stated accuracy, the minimum resistance connected to the output should not be less than 1 K Ohm.

6.5 CURRENT OUTPUT

The current output can be connected to a loop resistance of up to 300 Ohm without external power supply, and up to 1 K Ohm with 28 V dc external power supply (see Table 5 Maximum Allowed Loop Resistance and External Supply Voltage). This output is intended for use only with jumper configurations which determine voltage ranges ±1 V.

6.6 LIMITS

High/low limits are outputs at J1 that indicate respective high/low analog values. Each individual output is produced by its respective VMOS open drain transistor.

There is no need to disassemble the AO-2 module in order to adjust the limits. The trimmers are exposed by lifting the latch door on top of the AO-2 module.

6.7 EXTERNAL POWER SUPPLY

External power supply 15-28 V dc, is needed in current output applications, in two cases:

a. Current loop resistance is greater than 300 Ohm (but not more than 1 K Ohm). The relation between the maximum external supply voltage and maximum current loop resistance is shown in Table 5 Maximum Allowed Loop Resistance and External Supply Voltage.

b. More than two current outputs in the MRU are used, the reason being that the current on the VD line (12 V dc) of the MRU bus is limited to 100 mA.

NOTE

Assure that the total current consumption required by the output circuits (including the current produced by the AO-2 module) is less than the allowed maximum. It may be necessary to connect an external power supply if the current transfer is above the allowed maximum limit (even if only one current port is in use).

Table 5. Maximum Allowed Loop Resistance and External Supply Voltage

Rmax	Vdc External Power Supply
300	15
400	16.8
500	18.7
600	20.6
700	22.5
800	24.3
900	26.2
1000	28

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THEORY OF OPERATION

1. GENERAL

The Analog Output Module (AO-2) converts digital information into analog data and provides two analog channels, each with analog voltage and current outputs and high/low limits indication.

2. BLOCK DIAGRAM DESCRIPTION

(Refer to Figure 1 Analog Output Module Block Diagram.)

Port address and data bits are clocked serially (from the Decoder) into the internal shift register of the AO-2 module. The data is stored according to the specific address (one of eight ports) in internal memory and converted into analog voltage and current. When the LIMITS circuit senses the analog voltage, it provides the high and low limits. All connections (to the user connector) are surge protected by the surge protection circuit.

Additional shift registers enable the AO-2 module to clock out serial data to the Decoder. This data includes identification of the analog output module, and the group and preset value of each analog port.

The internal voltage references are provided by the 5 V dc and 12 V dc of the MRU BUS. The 12 V dc may be switched by the external Power Fail signal. Additional 15-28 V dc external power supply may be connected through the user connector for high-resistance current loop applications.

3. DETAILED DESCRIPTION

(Refer to the schematic diagram at the end of this manual)

3.1 DECODER SOFTWARE SUPPORT TO AO-2 MODULE

During power-up of the Decoder it searches all eight ports for analog output ports (JU5 or JU6), stores the port numbers and transmits the preset values to the specific ports according to the DIP switches on the AO-2 modules (S1-1 or S2-1). During operation, whenever the Decoder receives a valid codeword it searches the ports that refer to analog output and reads back their group address (see Table 3 Group Selection). If a group match occurs beween the received codeword and a specific analog port, the Decoder transmits the 10-bit digital data to that port.

NOTE

A group assigned to an analog output port will override a control output group assigned to the same port (if it exists).

An interrogation codeword must contain (in the group field) group addresses that are **not** assigned to analog output.

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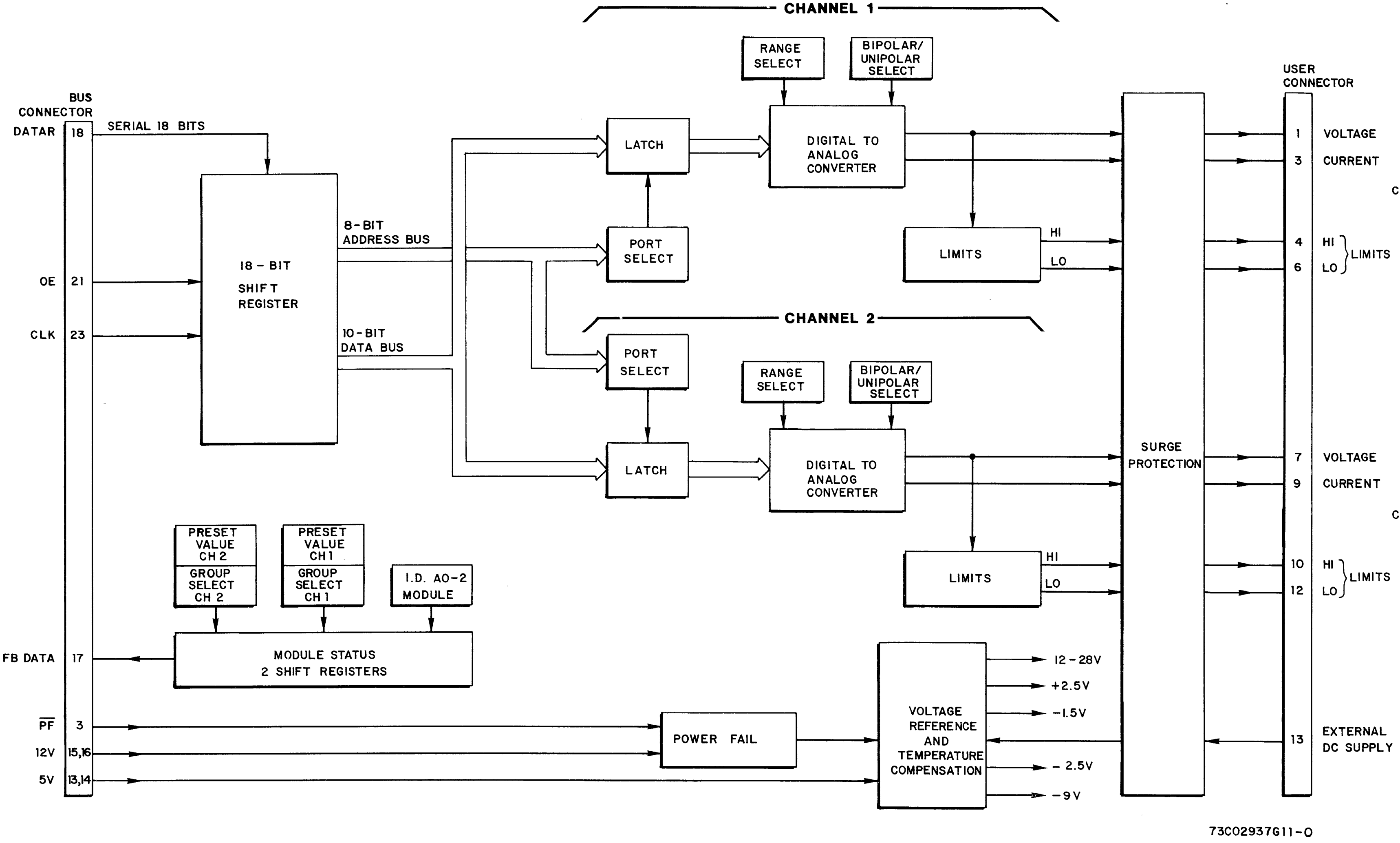


Figure 1. AO-2 Block Diagram

3.2 DECODER-ANALOG OUTPUT BUS COMMUNICATION

Communication between the two modules occurs on a bus which consists of four signal lines:

DATAR	18 bits which are transferred serially (synchronized by the CKR signal) into 18 bit shift register. Starting with 10 data bits (U15 and U20) and ending with 8 address bits (U11).
CKR	Provides synchronization of the data stream.
OE	When the OE line is held high the following information is latched into an internal shift register (U3 or U4) in the module:

- Identification of an analog output module.
- Group address according to the DIP switches (S1-2 to S1-4 or S2-2 to S2-4) with pull-up resistors U10 (see Table 3 Group Selection).
- Preset Value, one of two possible values depending on the DIP switch (S1-1 or S2-1 see Table 1 Jumpers and Switches).
- When the OE and the DATAR signals are held high, the 10-bit data is latched into the internal latches (U13, U18 or U11, U19) according to the address (port number). The analog output is being updated accordingly.

FBDATA	Signal line which enables the Decoder to read the internal shift register (U3 or U4) of a specific port.

3.3 DIGITAL TO ANALOG CONVERSION

The 10-bit digital data is stored in the internal latches (U13, U18 or U14, U9). A digital to analog converter AD7533 (U8 or U9) is used. The D/A converter is of type R-2R LADDRE and connected to temperature compensated - 2.5 V reference, with adjustable range (R26 or R27).

CR6, R25, C25 provide a reset pulse to all the latches immediately after connection of the AO-2 module to the 5 V power supply. This will bring forth the lowest analog value in the outputs until the Decoder transmits the preset value.

The current from the D/A converter is converted into voltage through operational amplifier (U2/a or U2/c) with selectable feedback resistors (R43 or R45) for range selection (1 V or 5 V).

Selectable offset is provided by additional operational amplifier (U2/b or U2/d) and enables bipolar/unipolar operation, and offset adjustment by R37 or R36.

3.4 VOLTAGE TO CURRENT CONVERSION

U6 U1/a Q1 (U7 U1/d Q2) is a voltage to current converter that provides the 4-20 mA analog current output at voltage range of ±1 V.

The current output is the voltage between pins 1 and 3 of U6 (U7) divided by the resistor R66 (R67). Hence, a connection of -1.5 V in reference to pin 3 of U6 (U7) converts the voltage range ±1 V to current 4-20 mA.

3.5 LIMITS

U1/a (U1/c) acts as a buffer and monitors the analog voltage (range 1 V, not dependent on the range jumper position JU1 or JU2) which is compared to an adjustable reference (R54 R58 or R46, R51) by four comparators (U12) that provide (together with the switching transistors Q3-Q6) the high and low limits of the two analog channels. R60, R63, R64, R65 provide a 2.5% hysteresis to the comparators.

3.6 VOLTAGE REFERENCES

A precise voltage reference (U21) supplies +2.5 V reference which is translated to -2.5 V, -1.5 V references (U16). The charge pump inverter inverts the +12 V to a negative -9 V supply for bipolar voltage output applications (U17 with CR2 and CR3). U16/a provides the -1.5 V reference to the voltage to current converter. R10 controls this reference and serves as an offset to the current output in both channels simultaneously. U16/d converts the +2.5 V reference to -2.5 V reference for the LIMIT and offset adjustments. U16/b and U16/c together with two termistors R18 and R24 provide -2.5 V non-linear temperature compensated reference for the digital to analog converter.

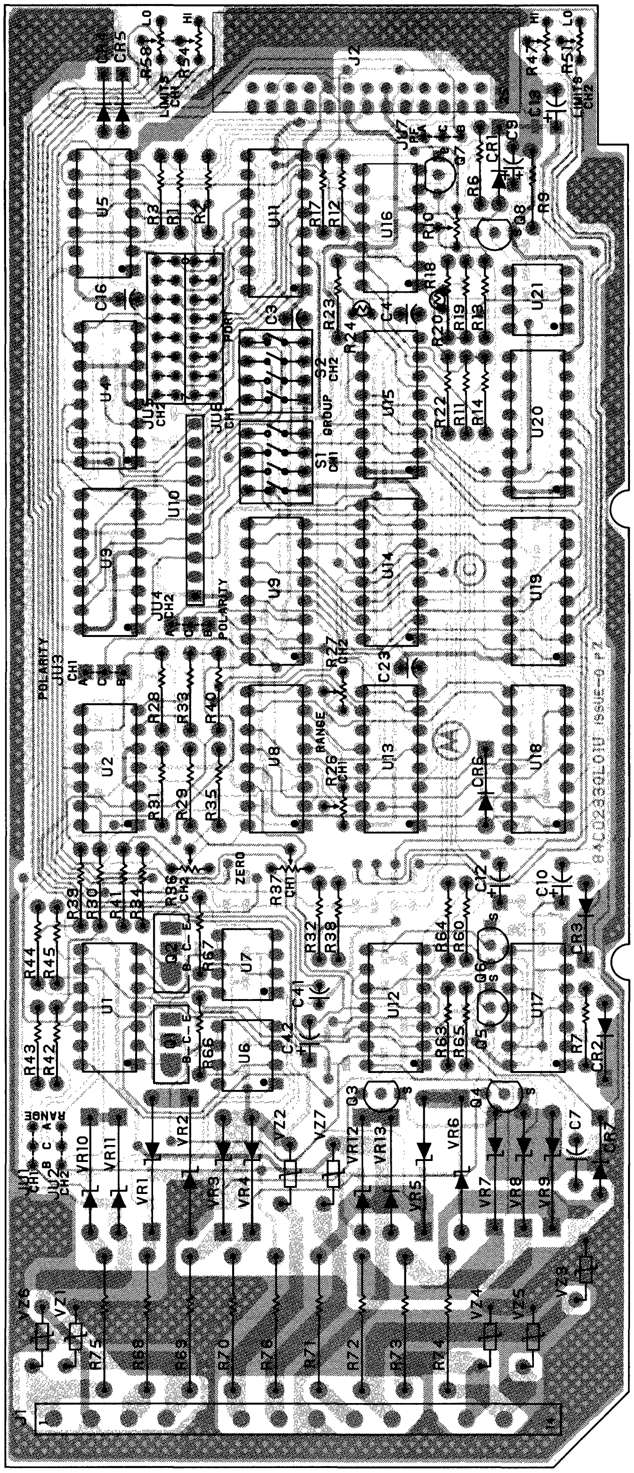
The 15 V-28 V external power supply is surge protected and connected only to the voltage to current converter.

3.7 POWER FAIL

This jumper selectable (JU7) option (not active by default) enables the external PF signal to switch the 12 V supply to the module (Q7, Q8) on/off for longer battery backup time. PNP transistor Q7 serves as the switch and is controlled by Q8 which is connected to the PF signal and saturates Q7 during regular operation. C6 provides approximately 1 sec delay to eliminate the effect of fast transients on the 12 V supply to the module.

3.8 SURGE PROTECTION

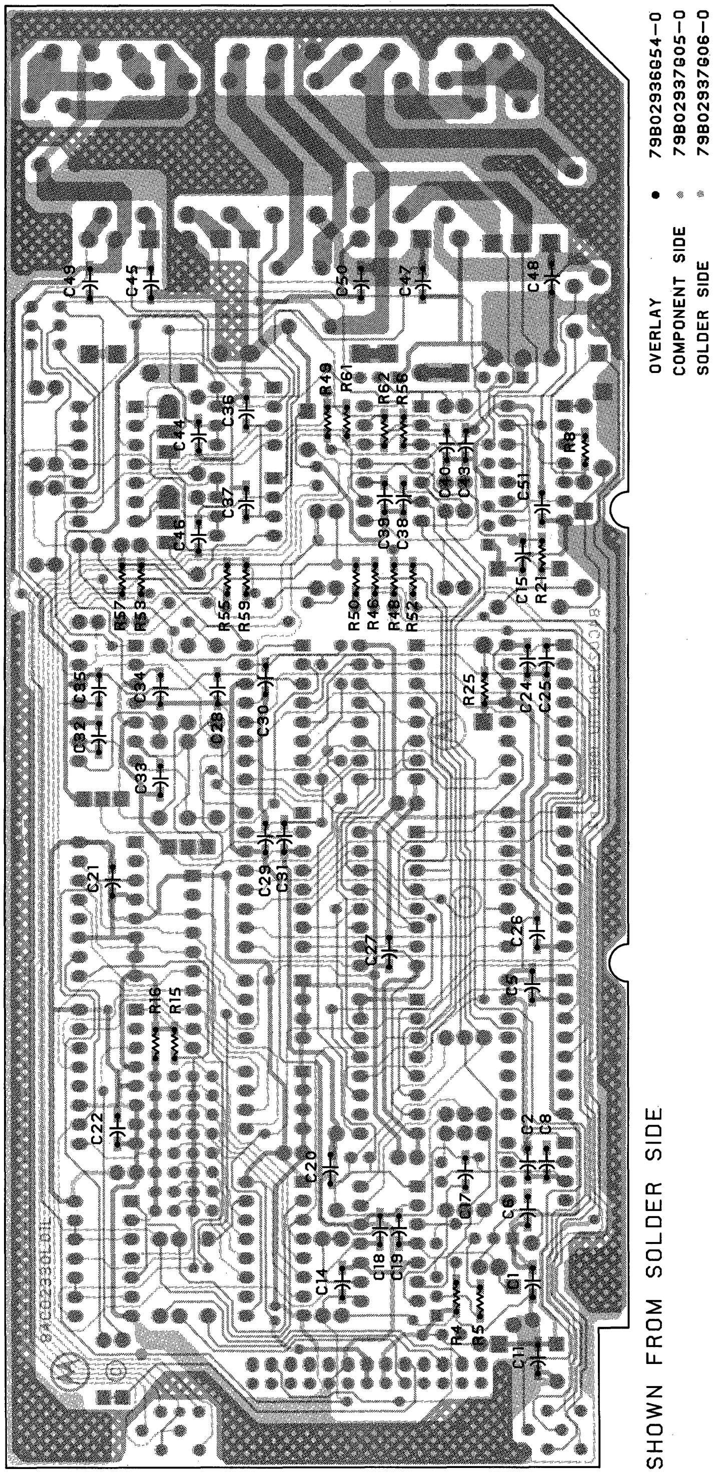
2 watt series resistors with parallel varistors and tranzorbs provide surge protection to all the outputs and external dc input of the module.



SHOWN FROM COMPONENT SIDE

OVERLAY • 79B02937G04-0
COMPONENT SIDE 79B02937G05-0
SOLDER SIDE 79B02937G06-0

FLN4344A Analog Output
Printed Circuit Board Detail
June, 1986



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FLN4344A Analog Output
Printed Circuit Board Detail
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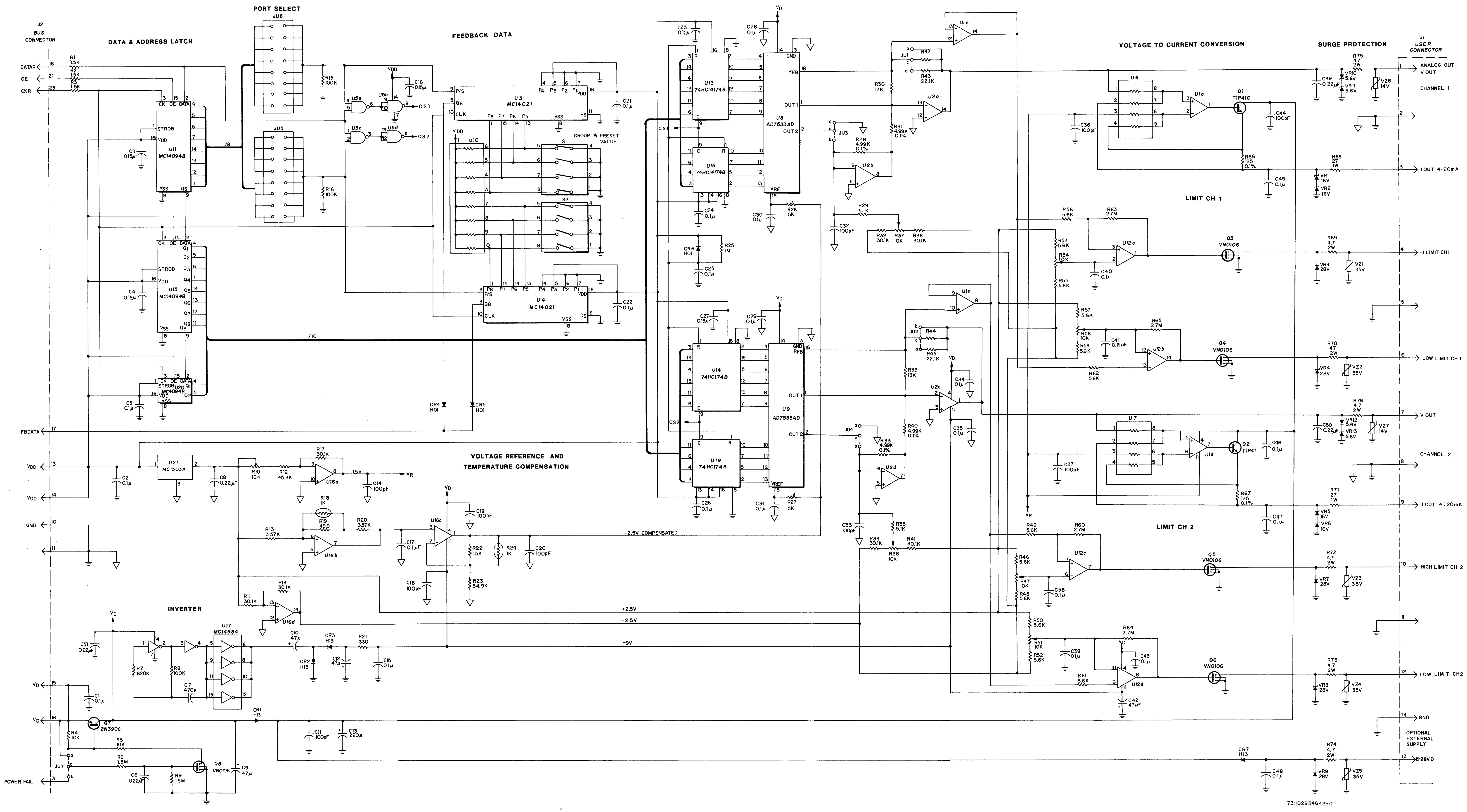

FLN4344A Analog Output
Schematic Diagram
June, 1986

parts lists

FLN4344A AO-2 Main Board PL-0376-O

Reference Symbol	Motorola Part No.	Description
		Capacitors
C1,2	21-11032B13	.10 uF 50 V, Chip
C3,4	21-84008H03	.15 uF 50 V
C5	21-11032B13	.10 uF 50 V, Chip
C6	21-11032	.22 uF 50 V, Chip
C7	21-84494B19	470 pF 300 V
C8	21-11032	.22 uF 50 V, Chip
C9,10	23-84538G06	47 uF 20 V
C11	21-11032A02	100 pF 50 V, Chip
C12	23-84538G06	47 uF 20 V
C13	23-08524G02	220 uF 35 V
C14	21-11032A02	100 pF 50 V, Chip
C15	21-11032B13	.10 uF 50 V, Chip
C16	21-84008H03	.15 uF 50 V
C17	21-11032B13	.10 uF 50 V, Chip
C18 thru 20	21-11032A02	100 pF 50 V, Chip
C21,22	21-11032B13	.10 uF 50 V, Chip
C23	21-84008H03	.15 uF 50 V
C24 thru 31	21-11032B13	.10 uF 50 V, Chip
C32,33	21-11032A02	100 pF 50 V, Chip
C34,35	21-11032B13	.10 uF 50 V, Chip
C36,37	21-11032A02	100 pF 50 V, Chip
C38 thru 40	21-11032B13	.10 uF 50 V, Chip
C41	21-84008H03	.15 uF 50 V
C42	23-84538G06	47 uF 20 V
C43	21-11032B13	.10 uF 50 V, Chip
C44	21-11032A02	100 pF 50 V, Chip
C45 thru 48	21-11032B13	.10 uF 50 V, Chip
C49 thru 51	21-11032B15	.022 uF 50 V, Chip
		Diodes
CR1 thru 3	48-82466H13	SLCN66H13 200 V
CR4 thru 6	48-83654H01	SLCN66H13 200 V
CR7	48-82466H13	SLCN66H13 200 V
		Connectors
J1	28-08508G04	14 pin
J2	28-08044H06	26 pin
		Transistors
Q1,2	48-02089C14	TRNS TIP4IC
Q3 thru 6	48-08237G05	TRNS VN0106N3
Q7	48-02088C02	TRNS 2N3906
Q8	48-08237G05	TRNS VN0106N3
		Resistors:ohms ±5% 1/4 W unless otherwise stated
R1 thru 3	06-02477C77	1.5k 1% 1/10 W
R4,5	06-110024A73	10k 1/8 W, Chip
R6	06-60075B23	1.5M 1% 1/8 W
R7	06-00124B20	820k
R8	06-11024A97	100k 1/8 W, Chip
R9	06-60075B23	1.5M 1% 1/8 Wter
R10	18-02467C01	10k Variable
R11	06-02479C02	30.1k 1% 1/10 W
R12	06-02479C18	45.3k 1% 1/10 W
R13	06-02478C13	3.57k 1% 1/10 W
R14	06-02479C02	30.1k 1% 1/10 W10 W
R15,16	06-11024A97	100k 1/8 W, Chip
R17	06-02479C02	30.1k 1% 1/10 W
R18	06-83600K02	Thermister 1k
R19	06-02170C39	49.9k 1% 1/10 W
R20	06-02478C13	3.57k 1% 1/10 W
R21	06-11024A37	330k 1/8 W
R22	06-02477C77	1.5k 1% 1/10 W
R23	06-02170C09	54.9k 1% 1/10 W
R24	06-83600K02	Thermister 1k
R25	06-11024B22	1M 1/8 W
R26,27	18-02467C32	5k Variable
R28	06-08563C11	4.99k 0.1% 1/2 W
R29	06-02478C27	5.11k 1% 1/10 W
R30	06-02478C66	13k 1%
R31	06-08563C11	4.99k 0.1% 1/2 W
R32	06-02479C02	30.1k 1% 1/10 W
R33	06-08563C11	4.99k 0.1% 1/2 W
R34	06-02479C02	30.1k 1% 1/10 W
R35	06-02478C27	5.11k 1% 1/10 W
R36,37	18-02467C01	10k Variable
R38	06-02479C02	30.1k 1% 1/10 W
R39	06-02478C66	13k 1%
R40	06-08563C11	4.99k 0.1% 1/2 W
R41	06-02479C02	30.1k 1% 1/10 W
R42	-----	not used
R43	06-02478C88	22.1k
R44	-----	not used
R45	06-02478C88	22.1k
R46	06-11024A67	5600 1/8 W, Chip
R47	18-02467C26	10k Variable
R48 thru 50	06-11024A67	5600 1/8 W, Chip
R51	18-02467C26	10k Variablel/4 W
R52,53	06-11024A67	5600 1/8 W, Chip
R54	18-02467C26	10k Variable
R55 thru 57	06-11024A67	5600 1/8 W, Chip
R58	18-02467C26	10k Variable
R59	06-11024A67	5600 1/8 W, Chip
R60	06-00185B32	2.7M 1/10 W
R61,R62	06-11024A67	5600 1/8 W, Chip
R63 thru 65	06-00185B32	2.7M 1/10 W
R66,67	06-08563C15	125 Ohm 0.1% 1/4 W
R68	06-00126A11	27 Ohm 1 W
R69,70	17-91547090	4.7 Ohm 2 W
R71	06-00126A11	27 Ohm 1 W
R72 thru 76	17-91547090	4.7 Ohm 2 W
		Switches
S1,2	40-83849F04	DIP 4 positions
		Integrated circuits
U1,2	51-83629M18	LM224
U3,4	51-02073C44	CMOS 4021
U5	51-08244G05	MC74HC00J
U6,7	51-02150C34	Network, 100k 0.1%
U8,9	51-02162C27	AD7533AD
U10	51-02599K01	Res. Network
U11	51-02581K44	CMOS 4094-8
U12	51-83629M18	LM224
U13,14	51-08244G23	MC74HC174
U15	51-02581K44	CMOS 4094-8
U16	51-83629M18	LM224
U17	51-02073C80	MC14584 BCL
U18,19	51-08244G23	MC74HC174
U20	51-02581K44	CMOS 4094-8
U21	51-02162C59	Voltage Reg. MC1503A
		Zener diodes
VR1,2	48-02064C88	1N6276A 16 V
VR3,4	48-02064C47	5362B 28 V
VR5,6	48-02064C88	1N6276A 16 V
VR7 thru 9	48-02064C47	5362B 28 V
VR10 thru 13	48-02064C24	1N5339B 5.6 V
		Varistors
VZ1 thru 5	06-02597K06	45 35 V
VZ6,7	06-02597K01	18 14 V
		Jumpers
JU1 thru 4	28-82622L01	Plug 3 pin
JU5,6	28-08522G03	Plug Header 16 pin
JU 7	28-82622L01	Plug 3 pin
	Non Referenced Items	
	84-02330L01	Printed Circuit Board
	29-02219K01	Mini Jumper

FLN4347A Housing PL-0346-O

Reference Symbol	Motorola Part No.	Description
	02-02427C01	lock nut, 4-40x1x.22"
	03-08026H05	captive screw, 8-32x7/8, 2 used
	03-82210E15	captive screw, 2 used
	15-08513H01	housing base
	15-08586G01	housing cover
	15-08587G01	housing door
	22-02482C02	dowel pin
	54-08049K01	parameter label
	54-08124H01	address label
	54-08635G04	front label

FLN5720 Hardware PL-0345-O

Reference Symbol	Motorola Part No.	Description
	01-02717G06	Terminal and Wire Assembly, includes:
	29-02231C07	terminal lug
	03-00129675	lock screw, 4-40x1/4, 2 used
	03-00134309	lock screw, 4-40x3/16
	03-08026H02	captive screw, 8-32x3/4, 2 used
	03-08302H01	tapping screw, 2 used
	31-08509G04	terminal with socket
	54-08125H01	connector label

Note: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

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MAINTENANCE

1. DISASSEMBLY

Refer to the disassembly instructions located in the Installation section in this manual, and disassemble the module in order to expose the board for adjustments (except for limit adjustment) and changing of jumpers (refer to Table 1 Jumpers and Switches, for jumper and switches information).

2. POWER FAIL ACTIVATION
(JU7)

JU7-a is connected by means of foil printed on the bottom of the PCB to eliminate PF activation. For ac PF activation cut the foil and connect (JU7-b).

3. PORTS
(JU6 - Channel 1 JU7 - Channel 2)

Choose a different port number 0-7 (by inserting a mini jumper) for each analog channel. In order to disable a channel, do not insert a jumper to the port connected to the specific channel. Do not use port numbers assigned to control outputs.

4. GROUPS
(S1-2,3,4 - Channel 1,
S2-2,3,4 - Channel 2.)

Choose a specific group A-H for each port. Do not choose groups assigned to control outputs. Refer to Table 3 Group Selection, for switch combinations.

5. ANALOG RANGE
(JU1 to JU4)

Choose the desired range for voltage and current by setting jumpers for each analog port. Set range, polarity and preset value according to Table 2 Analog Output.

6. PRESET VALUE
(S1-1 Channel 1, S2-1 Channel 2)

Choose the desired preset value according to Table 2 Analog Output (Preset Values column).

7. ADJUSTMENTS

Connect the Analog Output module to the MRU.

Power-up the system (prior to power-up, the ac and battery must be disconnected from the MRU) to allow the Decoder to recognize the analog output ports in the AO-2 module so as to transmit the preset values to those specific ports. The analog value at the analog ports will be according to the preset value (within about 20% accuracy).

Two trimmers are available for each analog channel; offset and range, plus one trimmer common to both channels that offsets the current outputs, (adjusting a trimmer clockwise will increase the value).

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Table 1. Jumpers and Switches

Switches/Jumpers	Position	Description
S1-1 (Preset value)	 Closed Open	Channel 1 Preset to 0 upon power-up Preset to -500 upon power-up
S1-2 S1-3 (Group) S1-4	Select Group A-H**	Channel 1 Select the group (i.e., all closed for group A etc.)
S2-1	 Closed Open	Channel 2 Preset to 0 upon power-up Preset to -500 upon power-up
S2-2 S2-3 (Group) S2-4	Select Group A-H**	Channel 2 Select the group (i.e., all closed for group A etc.)
JU1	 c-a c-b	Channel 1 5 V range 1 V range
JU2	 c-a c-b	Channel 2 5 V range 1 V range
JU3	 c-a c-b	Channel 1 Unipolar output 0-1 or 0-5 Bipolar output ±1 or ±5
JU4	 c-a c-b	Channel 2 Unipolar output 0-1 or 0-5 Bipolar output ±1 or ±5
JU5 (Port select)	Select port # 0-7**	Channel 1 Select port # (0 for port #0 etc.)
JU6 (Port select)	Select port # 0-7**	Channel 2 Select port # (0 for port #0 etc.)
JU7	c-a c-b	Power save during ac power fail No such mode

**Default set at factory according to module position.

Table 2. Analog Outputs

Analog Output		Preset Value S1-1 (S2-1)				Jumpers	
Voltage	Current	Open (-500)		Closed (0)		JU1 (JU2) Range	JU3 (JU4) Polarity
±1 V	4-20 mA	-1 V	4 mA	0 V	12 mA	b	b
0-1 V	--	0 V	--	0.5 V	--	b	a
±5 V	--	-5 V	--	0 V	--	a	b
0-5 V	--	0 V	--	2.5 V	--	a	a

-- not used

Table 3. Group Selection

GROUP CHANNEL 1	S1-2	S1-3	S1-4
GROUP CHANNEL 2	S2-2	S2-3	S2-4
A	0	0	0
B	0	0	1
C	0	1	0
D	0	1	1
E	1	0	0
F	1	0	1
G	1	1	0
H	1	1	1

0 = Closed
1 = Open

Two analog adjustment procedures are available:

a. Use the two internal preset values. Proceed as follows:

Step 1. Connect a dvm to the analog voltage outputs on the user connector.

Step 2. Choose the preset value representing 0 voltage (S1-1, S2-1 see Table 2 Analog Outputs).

Step 3. Disconnect the ac and the battery and power-up the MRU (by connecting the ac/battery or both).

Step 4. Adjust R37, R36 for zero voltage reading.

Step 5. Choose the second preset value.

Step 6. Repeat step 3.

Step 7. Adjust R26, R27 for analog reading according to Table 2 Analog Outputs (-FS for bipolar operation and 1/2 FS for unipolar operation).

Step 8.*If current output is needed, connect a current meter to one of the two current outputs of the module. Choose the preset value representing 12 mA (S1-1, S2-1 closed). Power-up the MRU and adjust R10 for 12 mA current reading.

b. Transmit the data from the test set or the central. Proceed as follows:

Transmit digital data representing 0 and FS and adjust the offset and range accordingly (as in a).

7.1 LIMITS ADJUSTMENT (R54, R47 HI LIMIT, R58 R51 LOW LIMIT)

There is no need to disassemble the module, open the latch door and transmit the desired LIMIT value to the analog port. Adjust the desired limit of that port via the trimmers (located near the bus connector) until there is an indication on the limit output (by Ohm meter or by switching a device), note that there is 2.5% hysteresis on the adjusted value.

---

* The jumpers should be according to ± 1 V range.

APPENDIX I

DIGITAL TO ANALOG CONVERSION FORMULAS AND TABLES

In order to calculate the analog value acccording to a given digital value use the following formula:

$$\text{analog value} = \frac{\text{analog hi} + \text{analog lo}}{2} + \frac{\text{analog hi} - \text{analog lo}}{1000} \text{ x digital value}$$

$$\text{digital value} = \frac{(\text{analog hi} + \text{analog lo})\text{x}500}{\text{analog lo} - \text{analog hi}} + \frac{1000}{\text{analog hi} - \text{analog lo}} \text{ x analog value}$$

The digital value is decimal from -512 to +511.

Analog hi is represented by +500 digital according to jumper configuration, refer to Table 3 Full Scale Values.

Analog lo is represented by -500 digital according to jumper configuration, refer to Table 3 Full Scale Values.

Table 3 Full Scale Values

Analog Range		Analog Hi		Analog Lo	
±1 V	4-20 mA	1 V	20 mA	-1 V	4 mA
0-1 V	---	1 V	---	0 V	---
±5 V	---	5 V	---	-5 V	---
0-5 V	---	5 V	---	0 V	---

INTRAC 2000
Modular Remote Unit
Analog Output

68P02937G55-O

MOTOROLA

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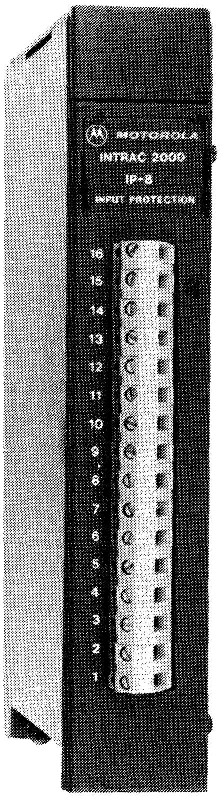
Modular Remote Unit
Input Protection



Instruction Manual

68P02940G85-0

COMMERCIAL WARRANTY
(STANDARD)

Motorola radio communications products are warranted to be free from defects in material and workmanship for a period of ONE (1) YEAR, (except for crystals and channel elements, which are warranted for a period of ten (10) years) from the date of shipment. Parts, including crystals and channel elements, will be replaced free of charge for the full warranty period, but the labor to replace defective parts will only be provided for One Hundred-Twenty (120) days from the date of shipment. Thereafter, purchaser must pay for the labor involved in repairing the product or replacing the parts at the prevailing rates together with any transportation charges to or from the place where warranty service is provided. This express warranty is extended by Motorola Communications and Electronics, Inc., 1301 Algonquin Road, Schaumburg, Illinois 60196, to the original purchaser only, and only to those purchasing for purpose of leasing or solely for commercial, industrial, or governmental use.

THIS WARRANTY IS GIVEN IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, WHICH ARE SPECIFICALLY EXCLUDED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL MOTOROLA BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW.

In the event of a defect, malfunction or failure to conform to specification established by SELLER, or if appropriate, to specifications accepted by Seller in writing, during the period shown, Motorola, at its option, will either repair or replace the product or refund the purchase price thereof, and such action on the part of Motorola shall be the full extent of Motorola's liability hereunder.

This warranty is void if:

a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage; and/or
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

The warranty extends only to individual products; batteries are excluded. Because each radio system is unique, Motorola disclaims liability for range, coverage, or operation of the system as a whole under this warranty except by a separate written agreement signed by an officer of Motorola.

LICENSED PROGRAMS: Motorola software provided in connection with this order is warranted to be free from reproducible defects for a period on ONE (1) YEAR. All material and labor to repair any such defects will be provided free of charge for the full warranty period, and SUBJECT TO THE DISCLAIMER IN BOLDFACE TYPE.

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In order to obtain performance of this warranty, purchasers must contact their Motorola sales person or Motorola at the address first above shown, attention Quality Assurance Department.

This warranty applies only within the United States.

EPS-30831-O

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EPS-34440-A

MOTOROLA INC.
Communications
Sector

INTRAC 2000®
Modular Remote Unit
Input Protection

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FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar equipment. The information it contains is current as of the printing date. Subsequent engineering changes are described in supplementary Instruction Manual Revisions (IMRs) issued as needed. The applicable schematic diagram is updated and the changes are described in a revision column printed either on the diagram or next to the corresponding parts list.

2. SERVICE

The Motorola National Service Organization offers one of the finest nationwide installation and maintenance programs available to communications equipment users. This organization comprises approximately 900 Motorola Service Stations located throughout the United States. Each Service Station is independently owned and operated, is staffed by one or more trained, FCC-licensed technicians, and is specially selected and authorized by Motorola.

The administrative staff of the National Service Organization consists of national, area and district service managers, and district representatives, all of whom are Motorola employees. Their objective is continually to improve the service to Motorola customers.

Motorola maintenance is available either on a time and material basis, or by means of a service contract. To obtain a service contract, contact your Motorola Service Representative, or write to:

National Service Manager
Motorola Communications and Electronics Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

3. MODEL AND KIT IDENTIFICATION

Every Motorola product is specifically identified by an overall model number printed on the nameplate. In addition, the assemblies and kits comprising the product usually have kit model numbers stamped on them.

4. REPLACEMENT PARTS ORDERING

Motorola maintains a **factory parts center** and several **area parts centers** located throughout the United States. These facilities are equipped to process parts orders, identify part numbers, and otherwise assist in the maintenance and repair of Motorola Communications Group products. The addresses of these parts centers are listed on the following page.

Orders for crystals, channel elements, active filters, PROMs, code plugs, and resonant reeds should be

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sent directly to the **factory parts center.** Orders for all other parts and for instruction manuals should be sent to the nearest **area parts center.**

All orders for replacement parts or equipment information should include the complete identification number. This requirement applies to all components, kits and chassis. If the component part number is not known, the order should include the number of the chassis or kit which uses it, and a description of the desired component sufficient to identify it.

Orders for crystals and channel elements should specify the crystal or channel element type number, crystal and carrier frequencies, and the model number of the chassis using the part.

Orders for active filters, PROMs, code plugs, and "Vibrasender" and "Vibrasponder" resonant reeds, should specify type number and frequency, and should identify the owner/operator of the communications system utilizing these items.

5. ADDRESSES

5.1 AREA PARTS CENTERS

5.1.1 U.S. Orders

Western Area Parts
1170 Chess Drive, Foster City
San Mateo, California 94404
Telephone: 415-349-3111
TWX: 910-375-3877

Midwest Area Parts
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-7322
TWX: 910-693-0869

Mid-Atlantic Area Parts
7230 Parkway Drive
Hanover, Maryland 20176
Telephone: 301-796-8600
TWX: 710-862-1941

East Central Area Parts
12995 Snow Road
Parma, Ohio 44130
Telephone: 216-267-2210
TWX: 810-421-8845

Eastern Area Parts
85 Harristown Road
Glen Rock, New Jersey 07452
Telephones: 201-447-4000
TWX: 710-988-5602

Pacific Southwestern Area Parts
P.O. Box 85036
San Diego, California 92138
Telephone: 714-578-2222
TWX: 910-335-1634

Gulf States Area Parts
8550 Katy Freeway, Suite 128
Houston, Texas 77024
Telephone: 713-932-8955

Southwestern Area Parts
P.O. Box 34290
3320 Belt Line Road
Dallas, Texas 75234
Telephone: 214-241-2151
TWX: 910-860-5505

Southeastern Area Parts
P.O. Box 368
Decatur, Georgia 30031
Telephone: 504-981-9800
TWX: 810-766-0876

5.1.2 Canadian Orders

Motorola Ltd.
National Parts Department
3125 Steeles Avenue
E. Willowdale, Ontario M2H 2H6
Telephone: 416-499-1441
TWX: 610-492-2713
Telex: 065-25191

5.1.3 All Other Countries

Motorola Inc., or
Motorola Americas, Inc.
International Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
U.S.A.
Telephone: 312-576-6492
TWX: 910-693-0869
Telex: 722443 or 722424
Cable: MOTOL PARTS

5.2 FACTORY PARTS CENTER

5.2.1 Mail Orders

Motorola, Inc.
Component Products Sales and Service
P.O. Box 66191
O'Hare International Airport
Chicago, Illinois 60666

5.2.2 Other Correspondence

Motorola, Inc.
Component Products Sales and Service
2553 N. Edgington Street
Franklin Park, Illinois 60131

5.3 GENERAL OFFICES

Motorola Communications and Electronics Inc.
Communications Group Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-3900

PERFORMANCE SPECIFICATIONS

GENERAL

Power Input	10 V-24 V DC or AC, 25 mA maximum
User Inputs	8 discrete inputs 16 terminals, 7.5mm spacing, AWG #14 Open > 10k ohm Close < 600 ohm (2 mA sink current through the user close contact)
Inputs Surge Protection	IEEE 472 3kV and IEEE 587 6kV 3kA 1.5kV 50 uF capacitor discharge All without damage and without false transmissions
Output	8 contacts (open drain) 5 ohm close contact maximum 50 V dc, .3A maximum ratings Surge detector output, open drain 5.5 V maximum
DC Isolation	3kV dc between user protective ground and MRU ground
Response Time	2 ms
Relative Humidity	95% at 40°C, without condensation
Housing	Thermo-plastic module
Dimensions	1.6" x 8.3" x 3.7" (H x W x D) 40.64 x 210.82 x 93.98mm (H x W x D)
Weight	402.8 gr 0.8844 lbs

KIT BREAKDOWN

FRN1641A Input Protection Module (IP-8)

FLN4580A Main Board
FLN5720A Hardware Main Board
FLN4582A Modular Housing
FLN4579A Label Kit

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SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.
2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.
3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.
5. Use only a grounded soldering iron.
6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

   WARNING

   If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.

MOTOROLA INC.
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INPUT PROTECTION
(IP-8)

1. GENERAL DESCRIPTION

The MRU Input Protection Module (IP-8) is part of the MRU family of products. It is configured in conjunction with either the Encoder (ES-8), Status Input (SI-8) or Counter Input (CI-6) modules.

The module provides improved surge protection, transient suppression and dc isolation for eight MRU discrete inputs thereby enabling them to operate in an extremely noisy environment which would otherwise subject the inputs to unacceptable noise pulses.

The IP-8 features are as follows:

- DC isolation (opto-couplers) of 3k V between the user inputs and the MRU discrete inputs. (Note that the eight user inputs share the same common return protective ground.)
- Surge protection and transient suppression to meet IEEE 472 3kV, IEEE 587 6kV 3kA standards, and 1.5kV 50 uF capacitor discharge, to avoid erroneous indications and change in stated module specifications.
- Detects transients and freezes (latches) the input states to prevent false reports even if a long transient is applied at the user inputs. At the same time it may provide notification to the central station whenever a freeze occurs. This feature can be used as a safety device by the central, when tampering with the unit is suspected.
- Freezes the 8 input states via an external control. The external control may be applied from two sources (refer to Figure 1. IP-8 to MRU Connections):

a. From the user connector - in place of input 8 (J2-15). It should be selected via JU1. In this configuration the user will have at his disposal 7 protected inputs, and input 8 will be reserved for the freeze application. When freeze occurs, it may be notified to the central station by connecting the freeze IN/OUT signal (J1-1) to one of the MRU status inputs. The signal itself is not frozen.

b. From the Central Station - through one of the MRU control outputs which will be connected to the unprotected input freeze IN/OUT line (J1-1). This application does not use one of the 8 user inputs.

2. INSTALLATION

2.1 GENERAL

The IP-8 module is housed in a shielded molded plastic housing. User connections are made via a 16 screw type terminal located on the front of the module (AWG. #14, 7.5 mm spacing)

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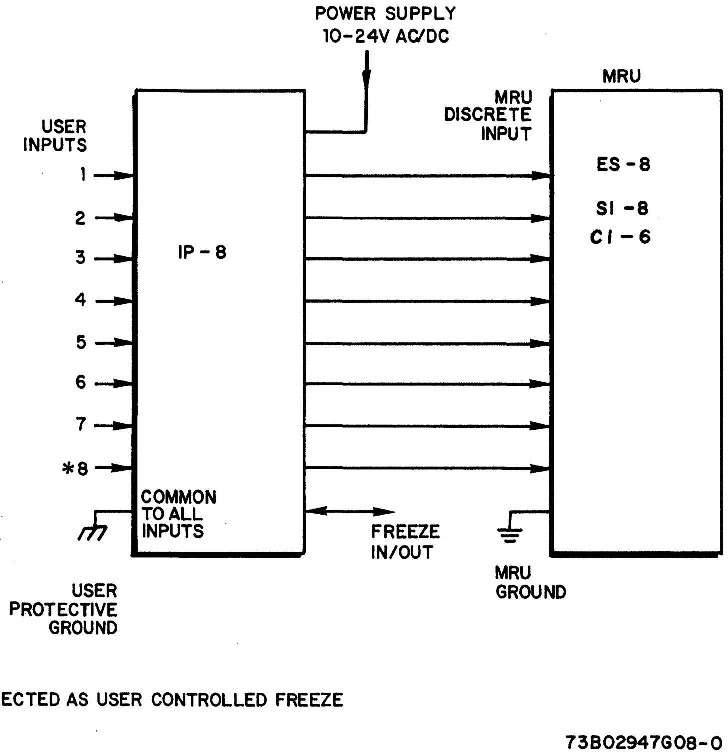


Figure 1. IP-8 to MRU Connections

providing a separate protective ground termination for each input. The connections to the MRU discrete inputs and to the power supply are made through a 14-pin screw type connector (AWG) located at the bottom of the module.

2.2 USER CONNECTIONS
Refer to Tables 1 and 2

2.2.1 Protective Ground

Connect an AWG #14 wire to the protective ground of one of the user inputs (J2) and connect the wire directly to a separate electrical ground (preferably a buried water pipe or any other direct earth ground). All eight protective ground terminals on the user connector (J2) are shorted within the module.

CAUTION
Do not connect the user inputs protective ground to the MRU GND.

2.2.2 User Inputs

Connect the user inputs (related to protective ground) according to Tables 1 and 2. Note that the input is defined as a dry contact (not as dc voltage levels) open > 10k ohm, close < 600 ohm. Connection of dc voltage greater than 10 V at the user inputs will freeze the output of the module (handled as a strong spike). This feature can be disabled by disconnecting JU1.

2.2.3 Connections to the MRU
(Refer to Table 2. MRU Connections.)

Connect the MRU inputs via a 14-terminal connector (J1) to the protected output of the IP-8 on the bottom of the module. Position the wires as far as possible from the user input wires.

It is **not** recommended to connect some of the user inputs directly to the MRU and others through the IP-8 module in a specific MRU module; the noisy inputs may conduct spikes to the unprotected inputs.

NOTE
A closed contact in the user input creates a closed contact (transistor switch) to the MRU.

2.2.4 Power Connection

Connect a 10-24 V ac/dc source, 25 mA, to terminals 13 and 14 of J1 in the IP-8 module. In the MRU configuration the connection is made as above on the Encoder or the Wireline module.

3. CIRCUIT DESCRIPTION

Refer to IP-8 Block Diagram

3.1 GENERAL

The user inputs (with separate grounding) are connected to the surge protection circuitry of the module. The surge protection circuitry also activates the surge detector. The input status is transferred to the latch via the opto-couplers (for dc isolation). The surge detector is connected to the control signal of the latch via the opto-coupler to freeze the latch when a surge is detected. The output of the latch is connected to eight VMOS transistors which provide an open drain contact to the MRU inputs.

The power to the module is converted to 5 V dc for the logic on the protected (quiet) side of the module, and to 6.2 V floating and isolated, to supply current to the opto-coupler on the noisy side of the module.

3.2 DETAILED DESCRIPTION

3.2.1 Surge Suppression

Three stages of surge suppression are provided:

a. 90 V 5kA spark gaps

b. 1k 1/2 W resistor with 14 V varistor

c. 0.5k resistor with 6.8 V zener diode.

Three levels of filterization are provided. The filters cut-off frequencies above 500 Hz and suppress fast transients.

a. 1.5k with 0.15 uF capacitor

b. 3k with 1 nF capacitor

c. 4.7 M with 4.7 nF capacitor.
Located on the opto-coupler base.

The diodes (CR1-CR8) in parallel with the opto-coupler diode protect the opto-coupler diode against reverse voltage spikes. A 24 ohm 1/2 W resistor (R25) separates the user protective ground from the internal floating GND to prevent strong currents inside the module.

3.2.2 Input Definition

V2 together with the opto-couplers specifications and the resistors at the input, set the input definition: open > 10k ohm, close < 600 ohm.

3.2.3 Surge Detector

Strong spikes at the input will also activate the zener diodes (VR1-VR8). The zener diode and an additional opto-coupler (U19) will short circuit the spikes to GND.

The diode bridge (CR9) detects positive and negative spikes and the opto-coupler (U19) transfers the information to the quiet side of the module in order to freeze the latch (U3). It takes the surge detector about 0.5 ms to respond (faster than the input response); the decay time is about 1 second based on the statistical assumption that noise and spikes appear in bursts.

Input Protection (IP-8)

Table 1. User Input Connections

J2 PIN #	USER INPUT
1	IN 1
2	Protective GND
3	IN 2
4	Protective GND
5	IN 3
6	Protective GND
7	IN 4
8	Protective GND
9	IN 5
10	Protective GND
11	IN 6
12	Protective GND
13	IN 7
14	Protective GND
* 15	IN 8
16	Protective GND

* Upon connecting JU1 it may be selected to freeze the other 7 inputs by the user (with isolated external control (if JU1 is connected)
IN 8: close = freeze
IN 8: open = unfreeze.

Table 2. MRU Connections

J1 PIN #	MRU Connection (to ES-8, SI-8, or CI-6 modules)
1	Freeze In/Out
2	Not used
3	Out 1
4	Out 2
5	Out 3
6	Out 4
7	MRU GND
8	Out 5
9	Out 6
10	Out 7
11	Out 8
12	MRU GND
** 13, 14	10-24 V ac/dc supply

** Connect to terminal points on Encoder or Wireline module.

Table 3. Jumper Settings

Jumper	Position	Description
JU1	Connected	J2/15 is an external freeze control input
	*Disconnected	J2/15 is input 8
JU2	*Connected	Enables freeze upon surge detection
	Disconnected	Disables freeze upon surge detection
JU3	------	Not used
JU4	------	Not used
JU5	*Connected	Factory use only
JU6	*C to B	Factory use only

* Default setting.

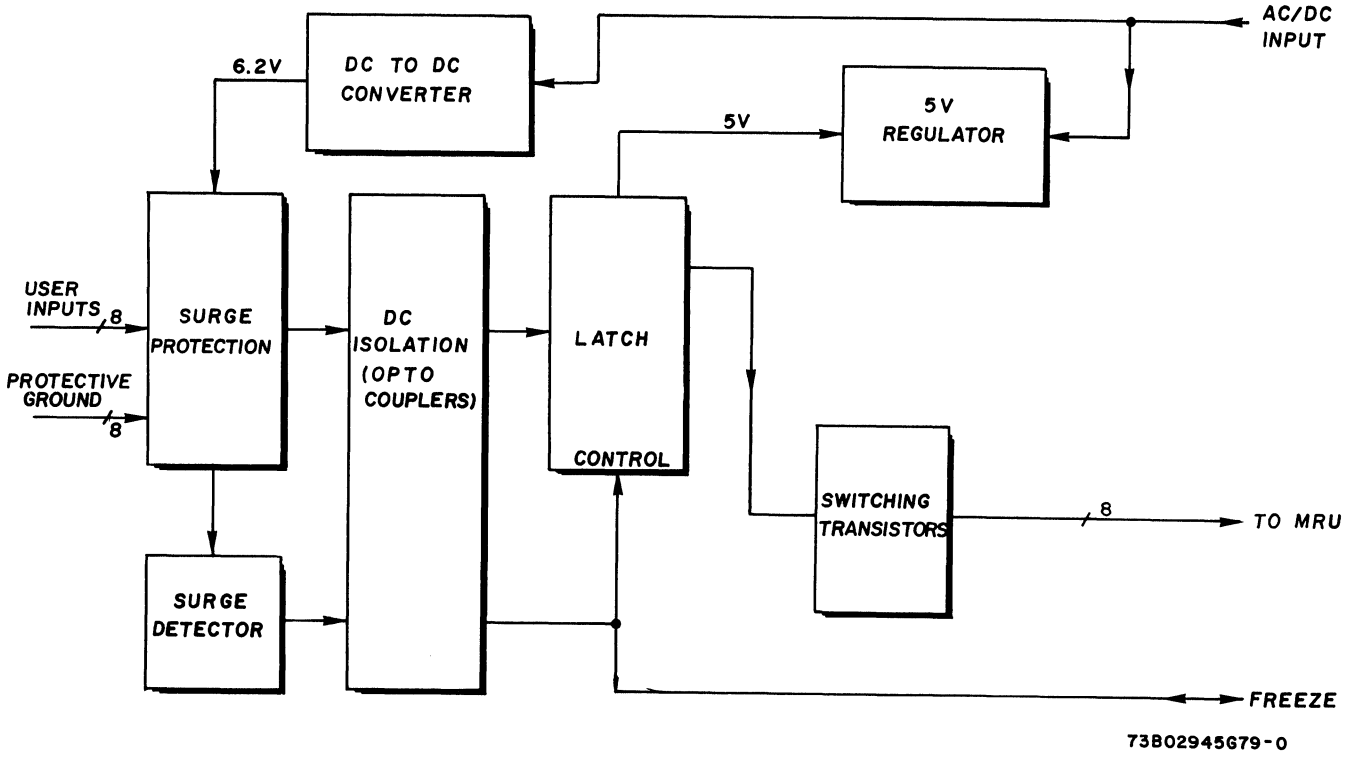


Figure 2. IP-8 Block Diagram

3.2.4 Latch (U3)

During normal operation the latch is dormant (an octal inverter). During surge detection it latches the input status. The latch may also be controlled by an external control via terminal 1 of J1 or via terminal 15 of J2 (isolated and protected) selected by JU1.

3.2.5 Output Transistors

Eight VMOS transistors (Q3-Q10) type VN0106 provide an open drain contact to the MRU discrete inputs.

3.2.6 Power Supply

The power supply may be dc or ac 10-24 V, this is rectified by the diode bridge (CR10), filtered by 220 uF capacitor (C28) and surge protected by a 35 V varistor (VZ1) and 33 V zener diode (VR9).

A 5 V regulator 7805 (U9) provides the supply to the logic on the quiet side of the module.

3.2.7 DC to DC Converter

A flyback dc to dc converter provides the 6.2 V dc to the opto-couplers on the noisy side of the module. It consists of a pulse width modulated oscillator (Z1) which feeds the VMOS transistor (Q2) that switches the transformer (T1). A fast recovery diode (CR11) with 1000 uF capacitor (C29) rectifies and filters the pulses on the secondary of the transformer. The TL431 (U18) precise reference, senses the dc voltage and activates an opto-coupler on the feedback to control the pulse width of the oscillator; this regulates the output voltage to 6.2 V dc.

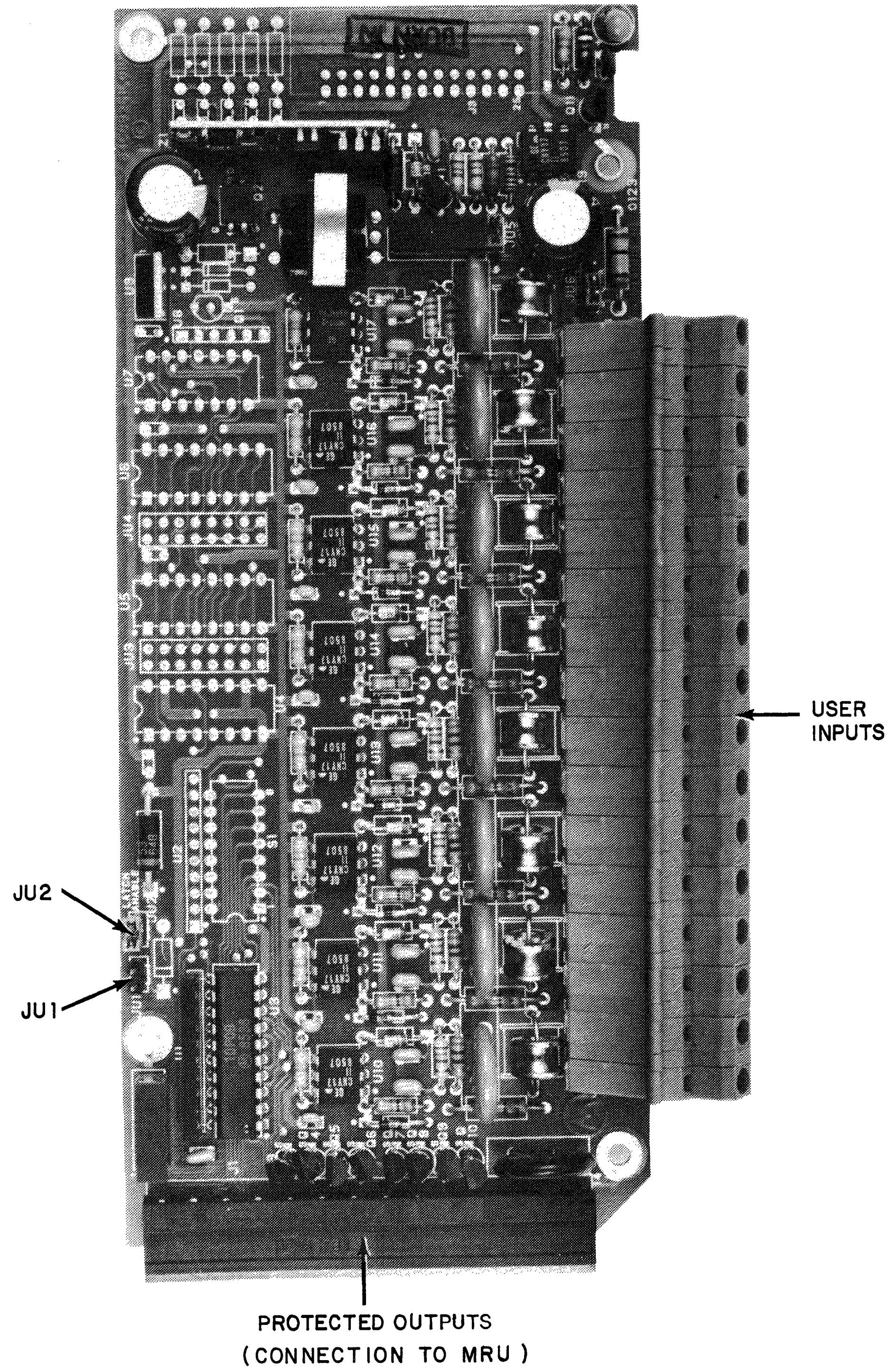
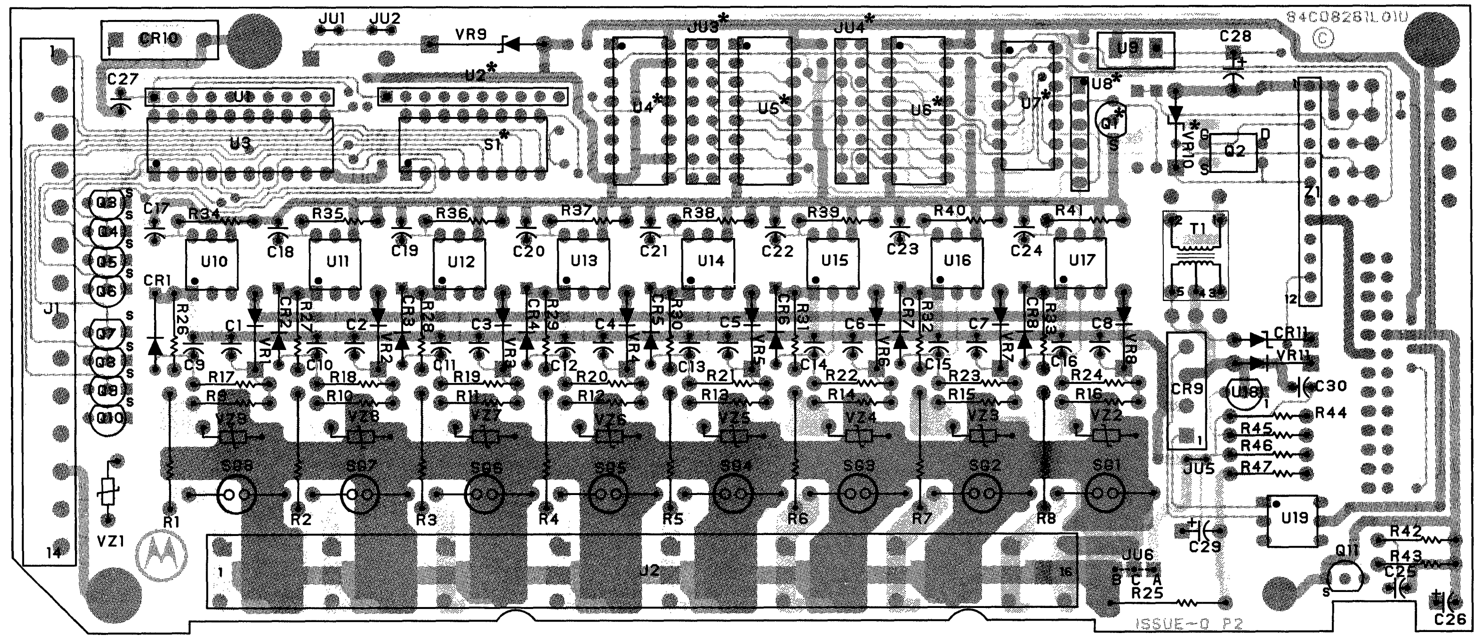


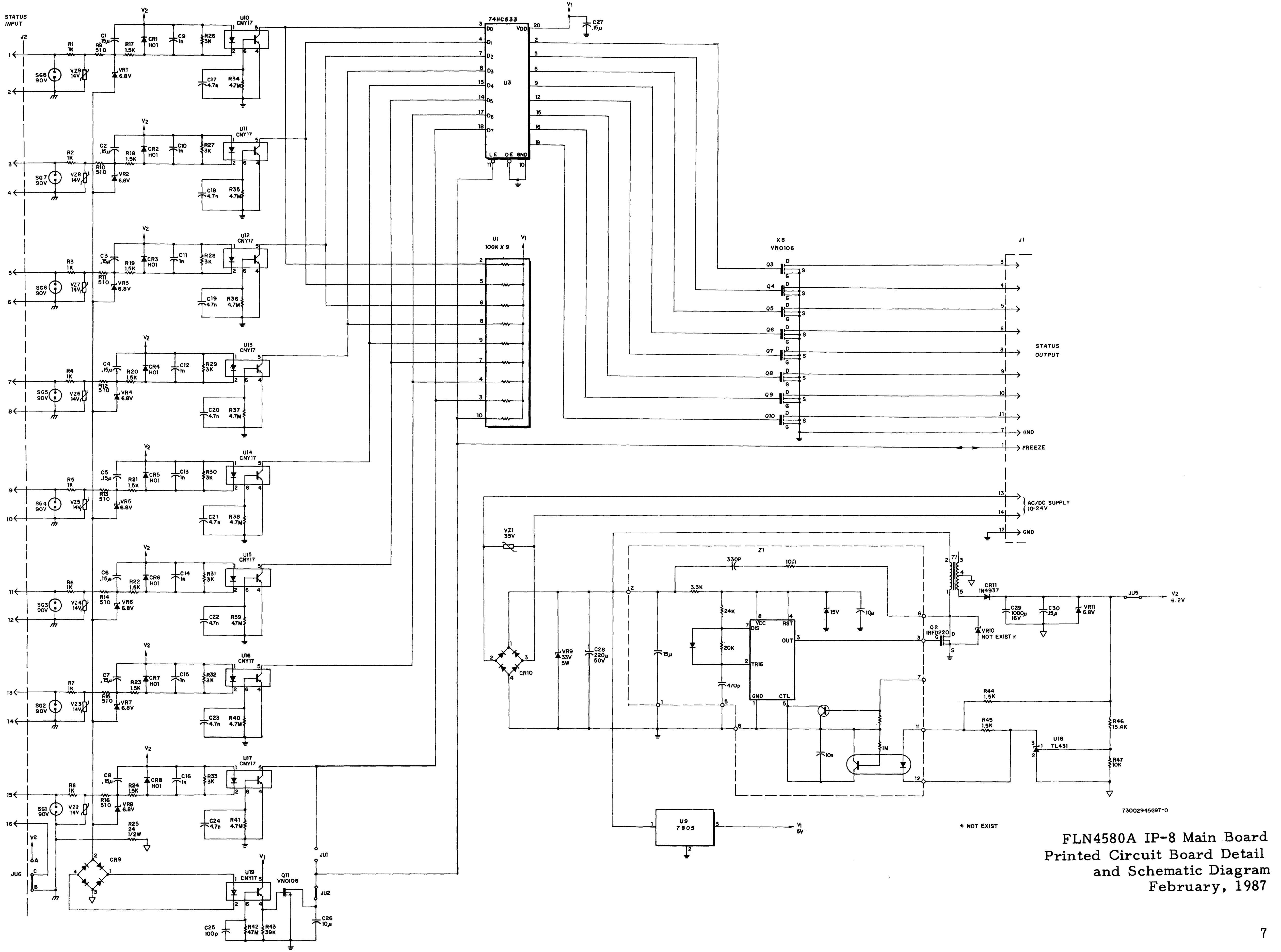
Figure 3. Printed Circuit Board



SHOWN FROM COMPONENT SIDE

* DOES NOT EXIST

OVERLAY	●	79A02948G32-0
COMPONENT SIDE	▨	79A02948G33-0
SOLDER SIDE	·	79A02948G34-0



FLN4580A IP-8 Main Board
Printed Circuit Board Detail
and Schematic Diagram
February, 1987

parts lists

FLN4580A IP-8 Main Board PL-0535-O

Reference Symbol	Motorola Part No.	Description
		Capacitor
C1 thru C8	21-84008H03	0.15 uF
C9 thru C16	21-02384C12	1 nF
C17 thru C24	21-08029H04	4.7 nF
C25	21-05455G01	100 pF
C26	23-84538G10	10 uF
C27	21-84008H03	0.15 uF
C28	23-02166L07	220 uF, 50 V
C29	23-02166L05	1000 uF 16 V
C30	21-84008H03	0.15 uF
		Diode (see note)
CR1 thru CR8	48-83654H01	H01
CR9, CR10	48-84621E04	diode bridge
CR11	48-02082C13	1N4937 600 V
		Connector
J1	28-08508G04	14-pin user connector
J2	31-02151C25	16-pin connector
		Jumper
JU1, JU2	28-02218K12	header 2X1; 2 used
	29-02219K01	jumper head
JU3 thru JU6	----	Not used
		Transistor (see note)
Q1	----	Not used
Q2	48-08237G08	IRFD 220
Q3 thru Q11	48-08237G05	VN0106
		Resistor, fixed ±5%
R1 thru R8	06-11045A49	1k 1/2W
R9 thru R16	06-11009C42	510 ohm 1/4W
R17 thru R24	06-11009C53	1.5k
R25	06-11045A10	24 ohm 1/2W
R26 thru R33	06-11009C60	3k
R34 thru R42	06-10164K50	4.7M 1/4W
R43	06-11009C87	39k
R44, R45	06-11009C53	1.5k
R46	06-10621D10	15.4k 1/4W 1%
R47	06-10621C91	10k 1/4W 1%
		Spark Gap
SG1 thru SG8	80-83029H03	90SG
		Transformer
T1	25-02154C08	transformer
		Integrated Circuit (see note)
U1	51-02599K01	100k x 9 CIP
U2	-----	Not used
U3	51-83810P09	74HC533
U4 thru U8	-----	Not used
U9	51-84320A47	7805
U10 thru U17	51-02169C16	CNY17
U18	51-83222M81	TL431
U19	51-02169C16	CNY17
		Zener Diode
VR1 thru VR8	48-91052352	6.8 V, 500 mW
VR9	48-02064C08	1N5364B, 33 V, 5W
VR10	-----	Not used
VR11	48-91052352	6.8 V, 500 mW

FLN4580A Main Board PL-0535-O

Reference Symbol	Motorola Part No.	Description
		Varistor
VZ1	06-02597K06	35 V
VZ2 thru VZ9	06-02597K01	14 V
		Hybrid
Z1	51-08401H01	hybrid
	Non Referenced Item	
	84-08261L01	printed circuit board

FLN4579A Label Kit PL-0536-O

Reference Symbol	Motorola Part No.	Description
	54-08635G06	Label

FLN5720A Hardware Kit PL-0381-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	01-02717G06	Terminal & wire subassembly; 1 used
	03-00129675	Lock scr 4x40x1/4 2 used
	03-00134309	Lock scr 4x40x3/16 1 used
	31-08509G04	14-pin user conn 1 used
	54-08125H01	Connector label, 1 used

FLN4582A Modular Housing PL-0537-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	02-02427C01	nut
	03-08026H05	screw
	03-82210E15	screw
	15-08513H01	housing base
	15-08656L01	housing cover
	15-08587G01	housing latch door
	22-02482C02	dowel pin

Note: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

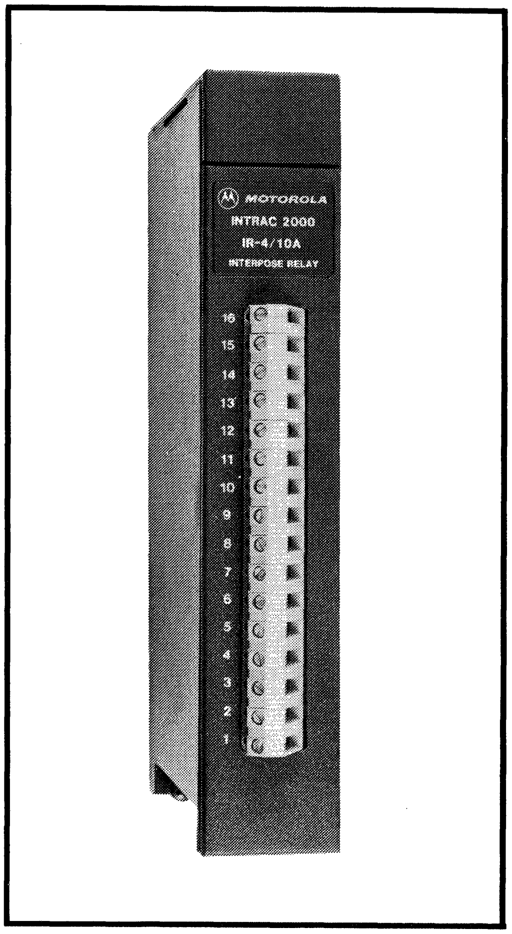
INTRAC 2000
Modular Remote Unit
Input Protection

68P02940G85-O

MOTOROLA

INTRAC 2000®

Modular Remote Unit Plus
4-Interpose Relays



Instruction Manual

68P02946G90-O

COMMERCIAL WARRANTY
(STANDARD)

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a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage;
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

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This warranty applies only within the United States.

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instruction manual revision

GENERAL

This revision details changes that should be made in your instruction manual. Please emend your manual accordingly.

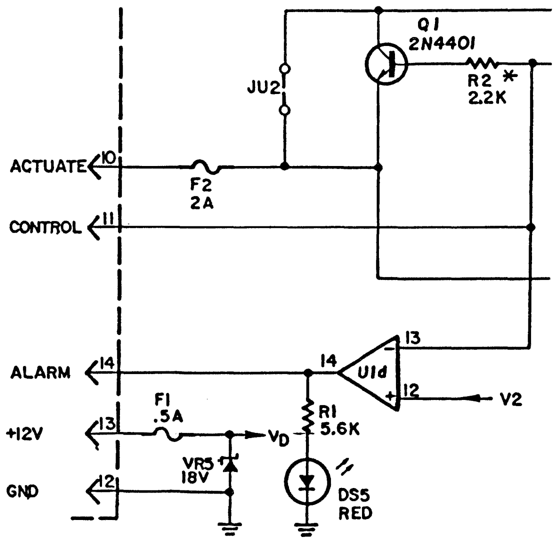
INSTRUCTION MANUAL AFFECTED

68P02946G90-O Modular Remote Unit Plus 4-Interpose Relays

REVISION DETAILS

1. Kit FLN4575A (Main Board of IR-4/10A) and kit FLN4800A (Main Board of IR-4/2A) have been changed. On each board the existing fuse (F1) has been moved and a new fuse (F2) has been added. In addition, a fifth Zener diode (VR5) has been added, as well.

2. The schematic diagram (page 11 of the manual) has been updated, and the section with the revision (the lower left-hand corner) is included below:

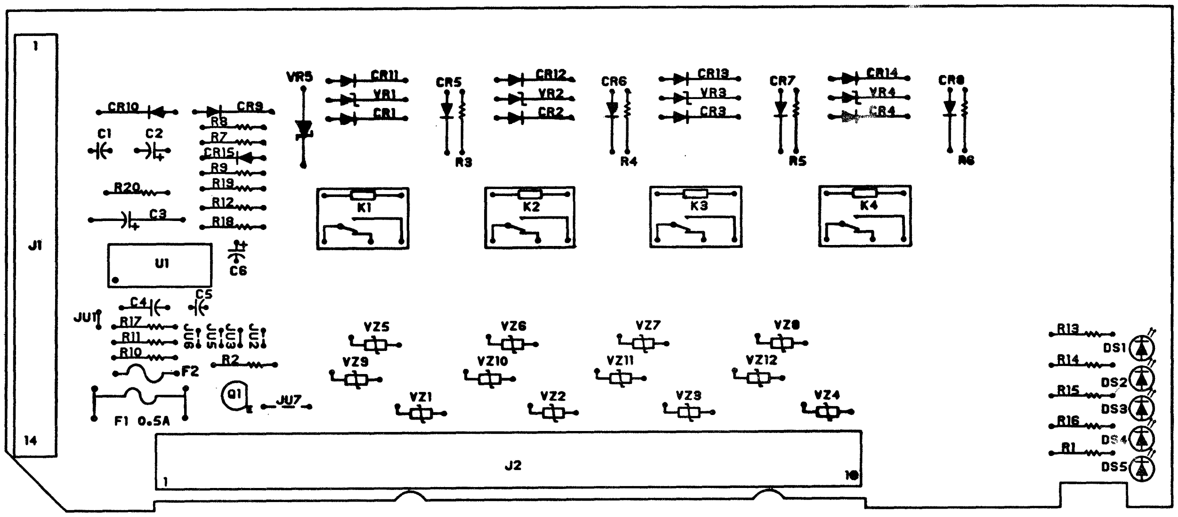


* R2 IS 5.6K ON IR-4/2A (FLN4800A)

3. The following changes should be made in the parts list:

Add:	F2	65-05214E01	Fuse, 2A
	VR5	48-83461E18	Zener Diode, 18 V

4. The printed circuit boards (page 10 of the manual) have been changed accordingly and the updated versions are included below:



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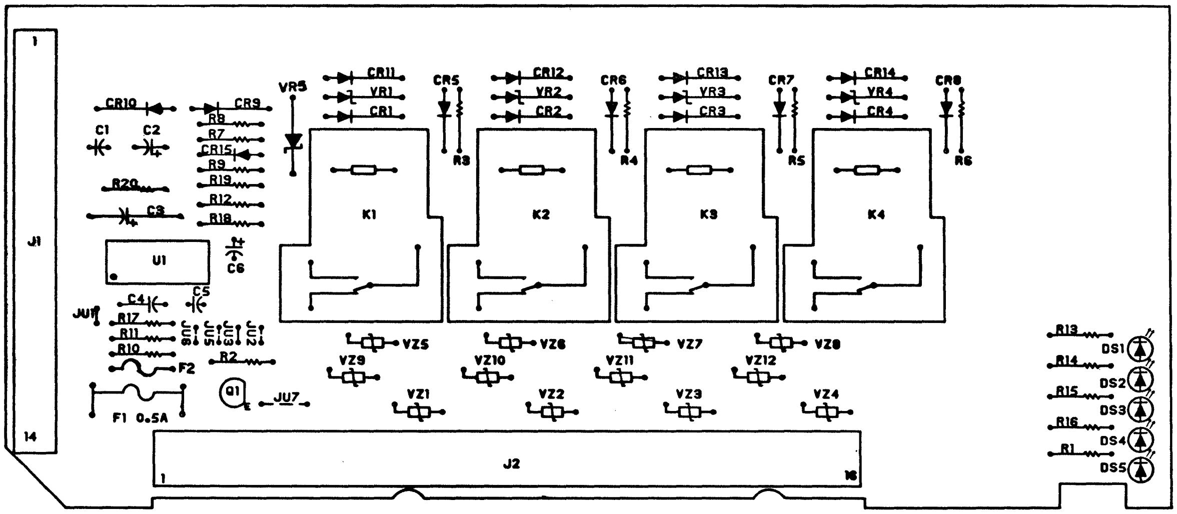
SOLDER SIDE • 79A02950074-A



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SOLDER SIDE • 79B02948031-A

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INTRAC 2000®
Modular Remote Unit Plus
4-Interpose Relays

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4-INTERPOSE RELAY **68P02946G90**
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FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar equipment. The information it contains is current as of the printing date. Subsequent engineering changes are described in supplementary Instruction Manual Revisions (IMRs) issued as needed. The applicable schematic diagram is updated and the changes are described in a revision column printed either on the diagram or next to the corresponding parts list.

2. SERVICE

The Motorola National Service Organization offers one of the finest nationwide installation and maintenance programs available to communications equipment users. This organization comprises approximately 900 Motorola Service Stations located throughout the United States. Each Service Station is independently owned and operated, is staffed by one or more trained, FCC-licensed technicians, and is specially selected and authorized by Motorola.

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National Service Manager
Motorola Communications and Electronics Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

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Every Motorola product is specifically identified by an overall model number printed on the nameplate. In addition, the assemblies and kits comprising the product usually have kit model numbers stamped on them.

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Orders for crystals, channel elements, active filters, PROMs, code plugs, and resonant reeds should be

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sent directly to the **factory parts center**. Orders for all other parts and for instruction manuals should be sent to the nearest **area parts center**.

All orders for replacement parts or equipment information should include the complete identification number. This requirement applies to all components, kits and chassis. If the component part number is not known, the order should include the number of the chassis or kit which uses it, and a description of the desired component sufficient to identify it.

Orders for crystals and channel elements should specify the crystal or channel element type number, crystal and carrier frequencies, and the model number of the chassis using the part.

Orders for active filters, PROMs, code plugs, and "Vibrasender" and "Vibrasponder" resonant reeds, should specify type number and frequency, and should identify the owner/operator of the communications system utilizing these items.

5. ADDRESSES

5.1 AREA PARTS CENTERS

5.1.1 U.S. Orders

Western Area Parts
1170 Chess Drive, Foster City
San Mateo, California 94404
Telephone: 415-349-3111
TWX: 910-375-3877

Midwest Area Parts
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-7322
TWX: 910-693-0869

Mid-Atlantic Area Parts
7230 Parkway Drive
Hanover, Maryland 20176
Telephone: 301-796-8600
TWX: 710-862-1941

East Central Area Parts
12995 Snow Road
Parma, Ohio 44130
Telephone: 216-267-2210
TWX: 810-421-8845

Eastern Area Parts
85 Harristown Road
Glen Rock, New Jersey 07452
Telephones: 201-447-4000
TWX: 710-988-5602

Pacific Southwestern Area Parts
P.O. Box 85036
San Diego, California 92138
Telephone: 714-578-2222
TWX: 910-335-1634

Gulf States Area Parts
8550 Katy Freeway, Suite 128
Houston, Texas 77024
Telephone: 713-932-8955

Southwestern Area Parts
P.O. Box 34290
3320 Belt Line Road
Dallas, Texas 75234
Telephone: 214-241-2151
TWX: 910-860-5505

Southeastern Area Parts
P.O. Box 368
Decatur, Georgia 30031
Telephone: 504-981-9800
TWX: 810-766-0876

5.1.2 Canadian Orders

Motorola Ltd.
National Parts Department
3125 Steeles Avenue
E. Willowdale, Ontario M2H 2H6
Telephone: 416-499-1441
TWX: 610-492-2713
Telex: 065-25191

5.1.3 All Other Countries

Motorola Inc., or
Motorola Americas, Inc.
International Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
U.S.A.
Telephone: 312-576-6492
TWX: 910-693-0869
Telex: 722443 or 722424
Cable: MOTOL PARTS

5.2 FACTORY PARTS CENTER

5.2.1 Mail Orders

Motorola, Inc.
Component Products Sales and Service
P.O. Box 66191
O'Hare International Airport
Chicago, Illinois 60666

5.2.2 Other Correspondence

Motorola, Inc.
Component Products Sales and Service
2553 N. Edgington Street
Franklin Park, Illinois 60131

5.3 GENERAL OFFICES

Motorola Communications and Electronics Inc.
Communications Group Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-3900

PERFORMANCE SPECIFICATIONS

GENERAL

Power Input	11-15 V dc max current consumption: 10 mA electronics; 450 mA relays (IR-4/10A), 160 mA relay (IR-4/2A)
Operating Temperature	-30°C to +60°C
Relative Humidity	0-90% without condensation
Housing	Thermo-plastic module
Dimensions	1.6" X 8.3" X 3.9" (HxWxD) 40.64 X 210.82 X 100 mm (HxWxD)
Weight	IR-4/10A 480 gr 1.344 lbs IR-4/2A 400 gr 1.120 lbs

RELAY OUTPUTS

Number of Relays	Four
Input and Output Connections	Screw type terminal strip, 16 terminals for AWG #14
Input Drive to Relays	IR-4/10A: 12 V dc, 78 mA nominal for each relay IR-4/2A: 12 V dc, 33 mA nominal for each relay
Contact Rating (10A)	AC rated (UL) 2-10 A @ 12-240 V inductive or resistive 1/4 HP @ 120 V motor 1/2 HP @ 240 V motor 3 A @ 240 V tungsten 3 A @ 277 V ballast DC rated (UL) 1-10 A @ 5-28 V resistive DC rated (manufacturer) 1-5 A @ 5-28 V inductive
Contact Rating (2A)	250 V ac maximum 2A maximum 125 VA maximum
Contact Type	Form C (changeover)
Relay type	Momentary (electrical)

KIT BREAKDOWNS

FRN1660A 4-Interpose Relay Module (IR-4/10A)

- FLN4575A Main Board
- FLN4630A Label Kit
- FLN4629A Hardware Kit
- FLN4582A Housing

FRN1733A 4-Interpose Relay Module (IR-4/2A)
- FLN4800A Main Board
- FLN4801A Label Kit
- FLN4629A Hardware Kit
- FLN4582A Housing

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SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.

2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.

3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.

5. Use only a grounded soldering iron.

6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

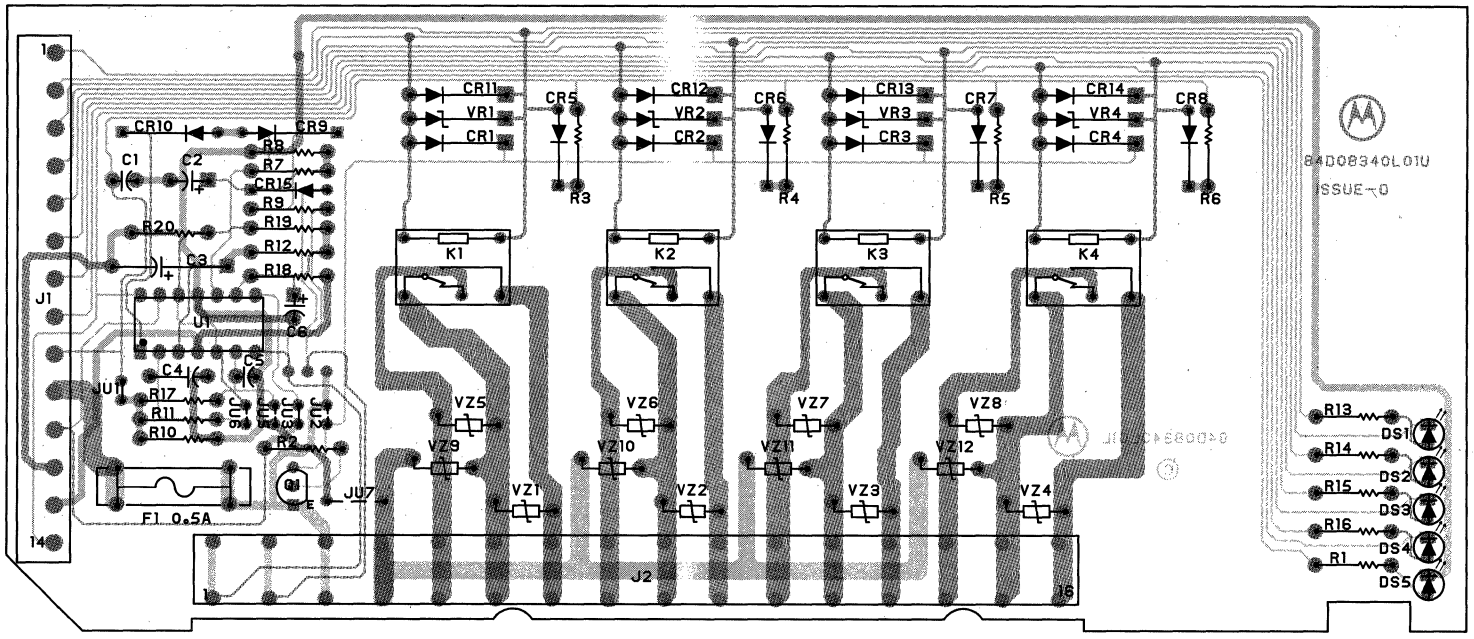
8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

WARNING

If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.



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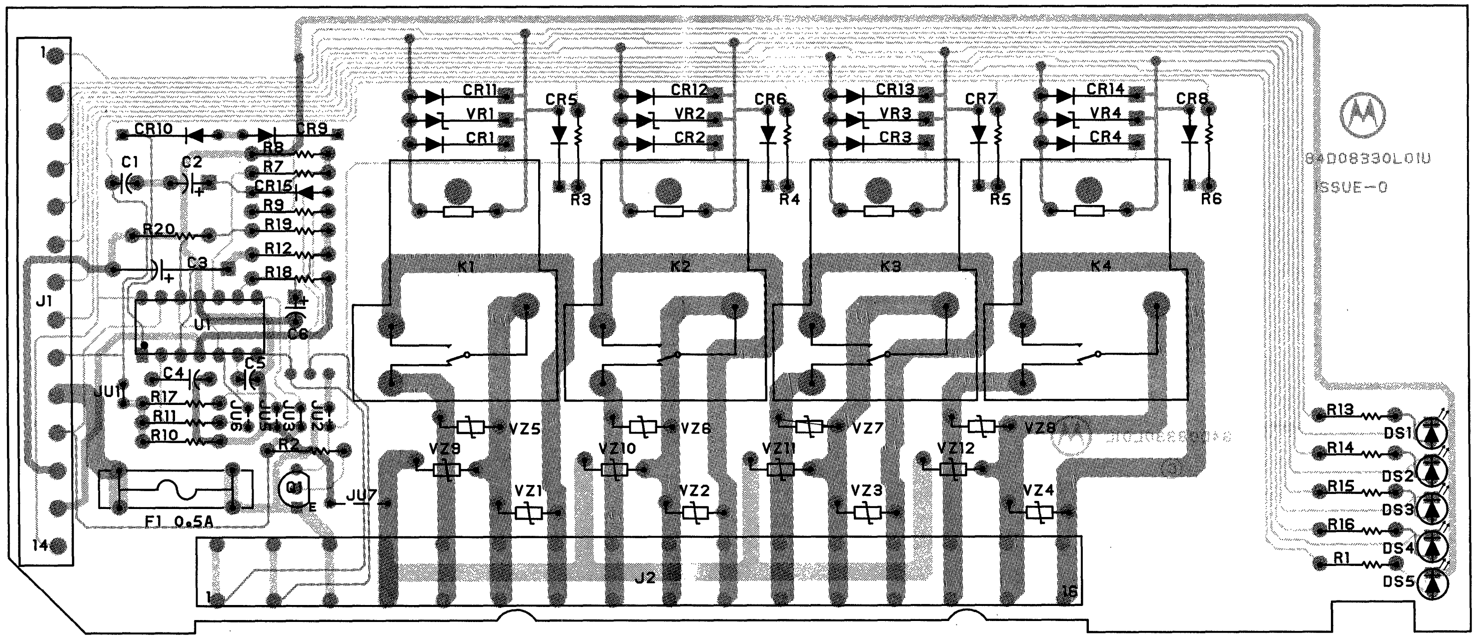

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SOLDER SIDE • 79B02948G31-0

FLN4575A IR-4/10A Main Board
FLN4800A IR-4/2A Main Board
Printed Circuit Board Detail
May, 1987

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GENERAL DESCRIPTION

1. GENERAL

The Modular Remote Unit Plus (MRU PLUS) 4-Interpose Relay Module (IR-4/10A) is an expansion module which provides four heavy duty relays, in addition to the lower rated relays contained in the Decoder (DC-4) or the Control Output Modules (CO-4, CO-8).

The MRU PLUS 4-Interpose Relay Module (IR-4/2A) is an expansion module with the same functions as the heavy duty relays (10A) but with lower rated relays, suitable for interfacing to external low current control logic.

The IR-4 is housed in a molded plastic housing. User input connections are provided by a removable screw-type terminal board (user connector) located at the bottom of the module. User output connections are provided by a fixed 16-terminal screw-type terminal board (output connector) located at the side of the module.

The IR-4/10A module may be ordered as an option (V100AA) or as an accessory (FRN1660). The IR-4/2A module may be ordered as an option (V100AB) or as an accessory (FRN1733).

Each relay is powered by applying 12 V dc to its SELECT and GND connections from one of the relays on the Decoder or Control Output modules. The 12 V can be supplied from the MRU's supply or from an external power supply (see Figure 5a).

A relay can also be selected by applying 12 V dc to its SELECT input and powered by connecting ACTUATE to ground. When the above mode is chosen a supervisory safety circuit controls the relay actuation (see Figure 5b).

1.1 SYSTEM CONFIGURATION

Various configurations are available for the IR-4 in a MRU PLUS system. Some examples of possible configurations are shown in Figures 5a, 5b, 5c and 5d.

1.2 POWER SUPPLY

The power supply to the IR-4 depends on the specific remote station configuration. Refer to Figures 5a, 5b, 5c and 5d for examples of various configurations.

1.3 SAFETY CIRCUIT

The safety circuit has the capability of monitoring one to three IR-4 modules and provides the following features:

a. Power-up delay: for 5 seconds after power-up, no relay can be selected or actuated. This allows time for the other modules to set their default parameters. If a SELECT is powered-up, the ALARM is set high and the red LED is lit during the power-up delay. The alarm is reset by removing power from the SELECT input/s and disconnecting ACTUATE from ground.

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b. Select time-out: a 30 second time-out is started when a SELECT input is powered-up. At the end of the time-out, the ACTUATE is disabled, the ALARM is set high and the red LED is lit. The time-out is reset by removing power from the SELECT input/s and disconnecting ACTUATE from ground. The time-out is disabled via a jumper.

c. Actuate time-out: a 5 second time-out is started when ACTUATE goes low for the first time. At the end of this time-out, the ACTUATE is disabled, the ALARM is set high and the red LED is lit. The time-out is reset by removing power from the SELECT input/s and disconnecting ACTUATE from ground. The time-out is disabled via a jumper.

d. Select-and-Actuate: the separate time-outs for SELECT and ACTUATE are used when a select and separate actuate sequence of relay control is being used. An additional jumper-selected option allows ACTUATE to be grounded continuously and provides internal actuation of the relay/s when SELECT is powered-up, with a timeout of 5 seconds. This provides momentary relay operation.

e. Single Select: this feature prevents the selection of more than one relay at the same time. If one SELECT is powered and an attempt is made to power-up a second SELECT, or two or more SELECT's are powered-up simultaneously, the ACTUATE is disabled, the ALARM is set high and the red LED is lit. The circuit is reset by removing power from the SELECT input/s and disconnecting ACTUATE from ground. This circuit is disabled via a jumper.

f. Monitor Functions: an additional jumper disables the safety circuit's control over ACTUATE, but leaves the ALARM and red LED operational indicating the various conditions as described above.

1.5 OPERATION WITH TWO OR THREE MODULES

One safety circuit can monitor and control up to three IR-4 modules. The second/third module has its safety circuit disabled and is connected to the first module as described in the Theory of Operation (see Figure 5c and 5d).

2. INSTALLATION

2.1 PRELIMINARY

Carefully inspect the IR-4 immediately on receipt and notify the shipper of any damage that has occurred in transit. The installation procedure consists of mounting the housing and making the necessary electrical connections.

2.2 MOUNTING

Mount the unit to the MRU chassis through the holes provided for that purpose in the housing. Figure 1. Housing Detail, shows the location of the mounting holes.

Mount the IR-4 on the mounting plate at the extreme right (the IR-4 should be the last module on the mounting plate).

2.3 DISASSEMBLY

(Refer to Figure 2. Disassembly)

Step 1. Loosen the two captive screws on the right panel of the IR-4 module housing.

Step 2. Assure that the latch door is open.

Step 3. Gently separate the two sides, exposing the printed circuit board (PCB).

2.4 JUMPERS

Changing jumper settings is best performed first before any connections are made to the IR-4 module.

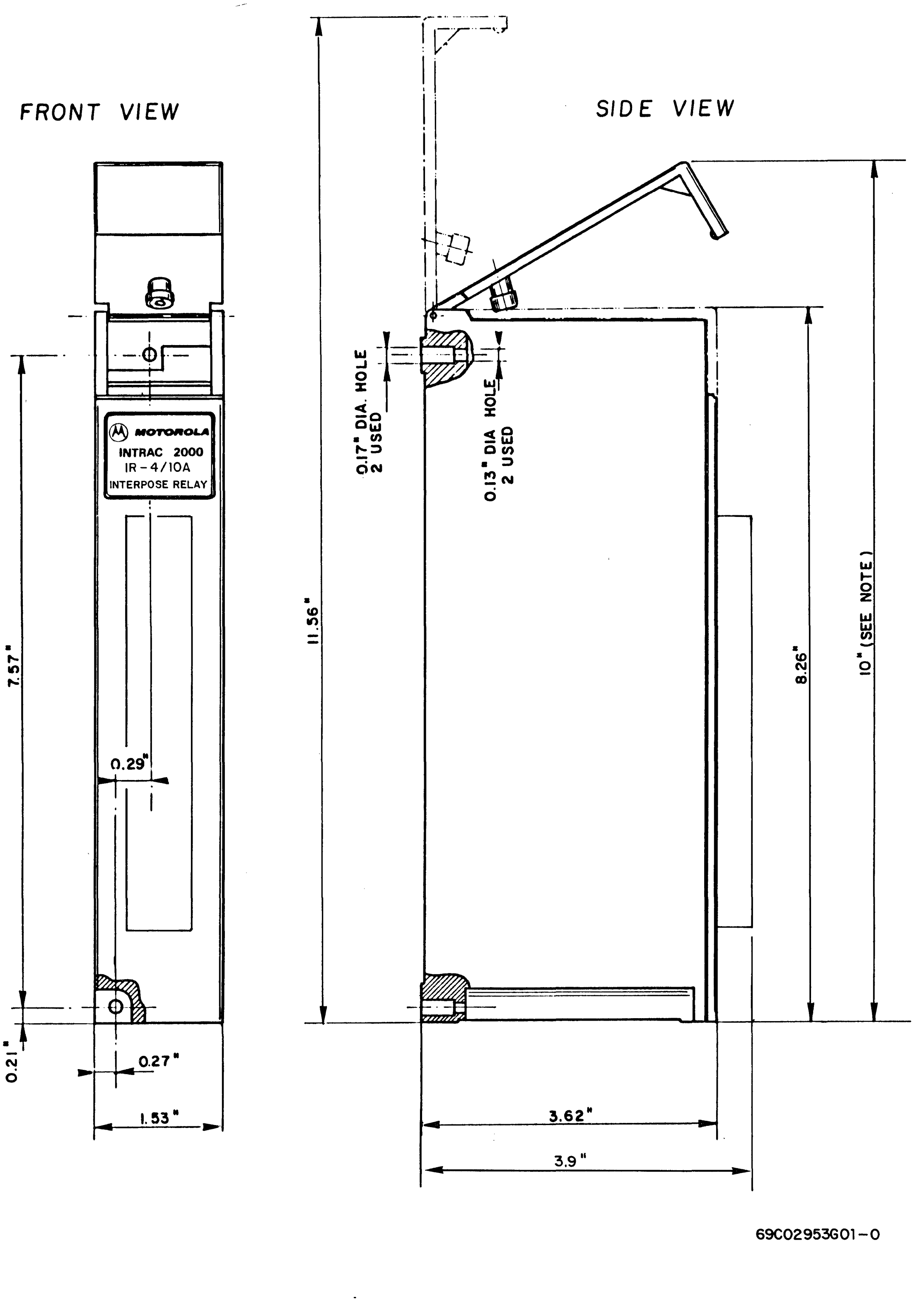


Figure 1. Housing Detail

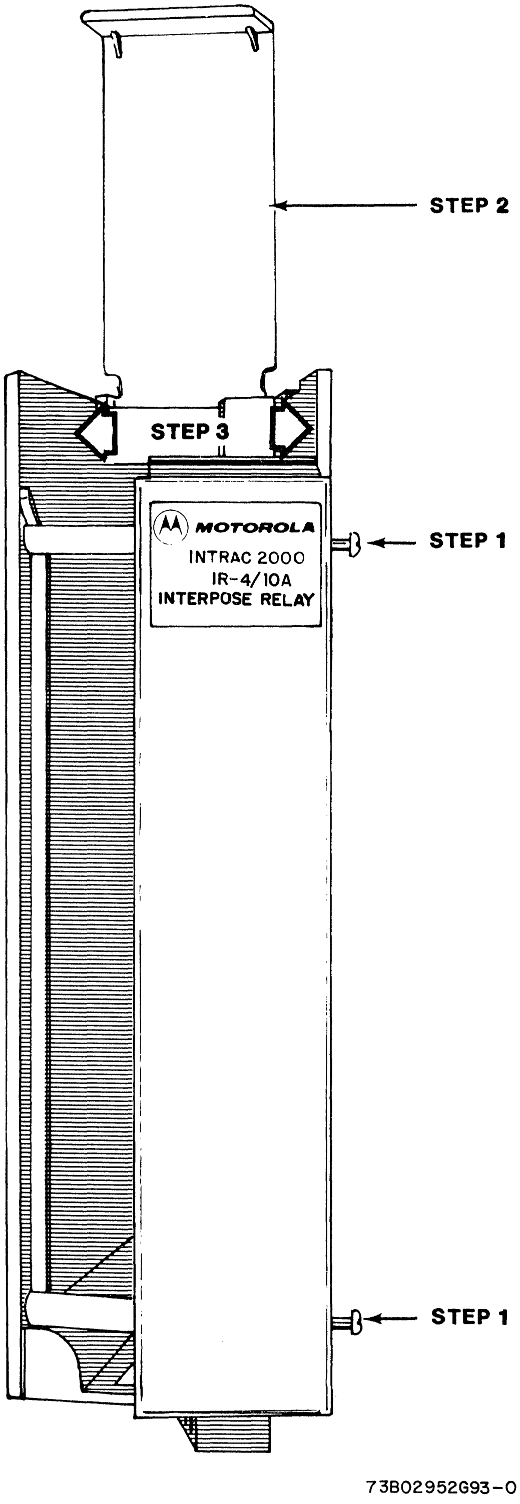


Figure 2. Disassembly

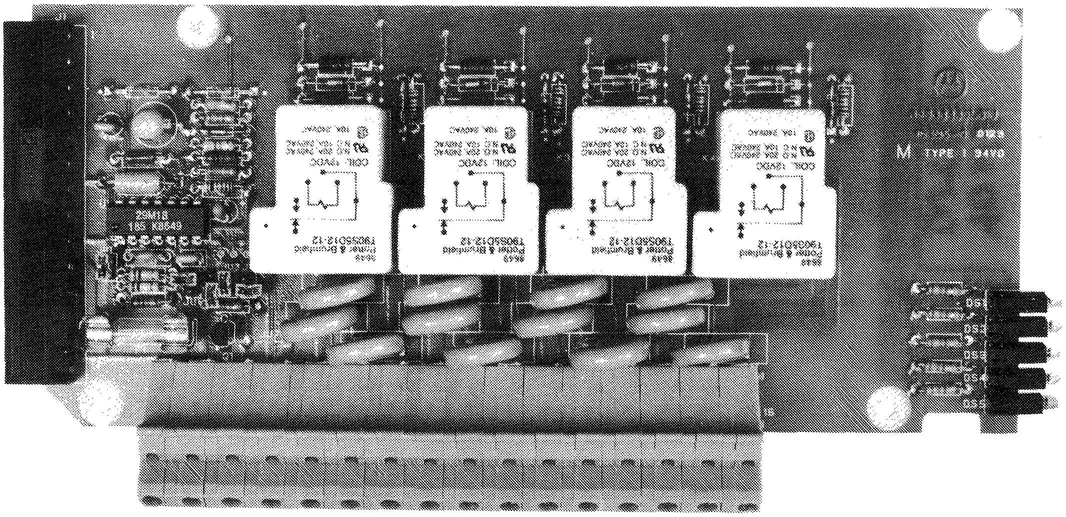
Table 1. IR-4 Jumpers

JUMPER	CONNECTION	FUNCTION
JU1	Not connected	Module controlled by other IR-4
	Connected*	Module controlled by its own circuit
JU2	Not connected*	Safety circuit monitors and controls relays
	Connected	Safety circuit monitors only
JU3	Not connected	Module controlled by other IR-4
	Connected*	Module controlled by its own circuit
JU4	-----	Not used
JU5	Not connected*	Select time-out enabled
	Connected	Select time-out disabled
JU6	Not connected*	Single relay at a time allowed
	Connected	Any number of relays can be selected
JU7	Not connected*	Protective ground not connected to supply ground.

Jumper Wire on Output Connector (J2)

	Not connected*	30 sec select time-out only
	Pin 1 to Pin 2	5 sec time-out from select only (momentary)
	Pin 2 to Pin 3	5 sec time-out from actuate (select and actuate)

* Factory default



NOTE:

The IR-4/2A printed circuit board is identical to the IR-4/10A printed circuit board shown above except for the relays which are 2A.

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Figure 3. IR-4/10A Board

4-Interpose Relay (IR-4)

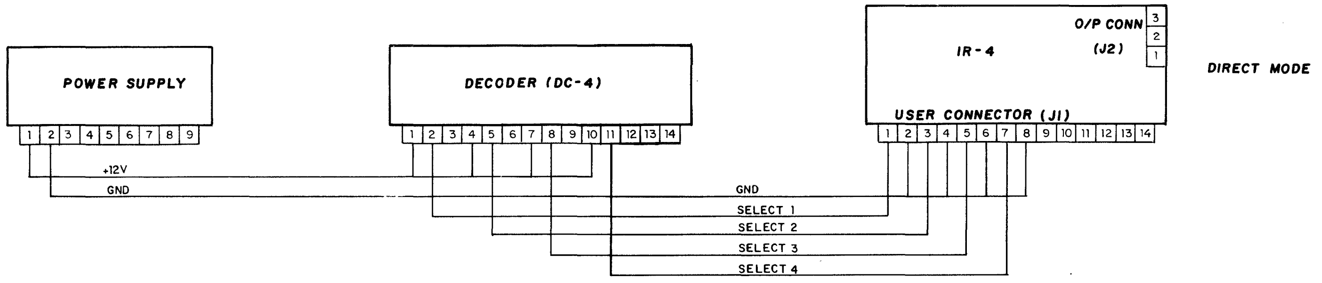
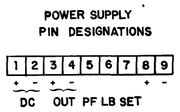


FIGURE 5a



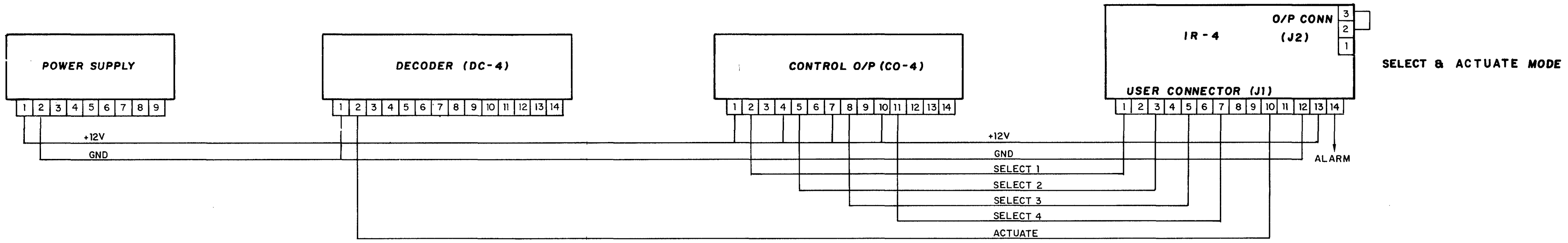


FIGURE 5b

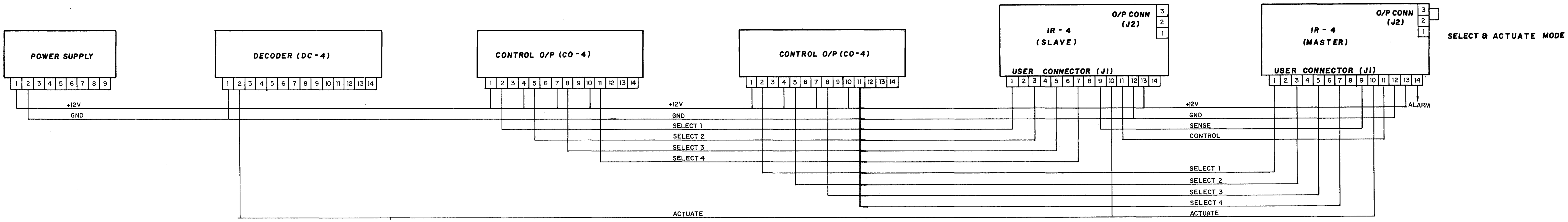


FIGURE 5c

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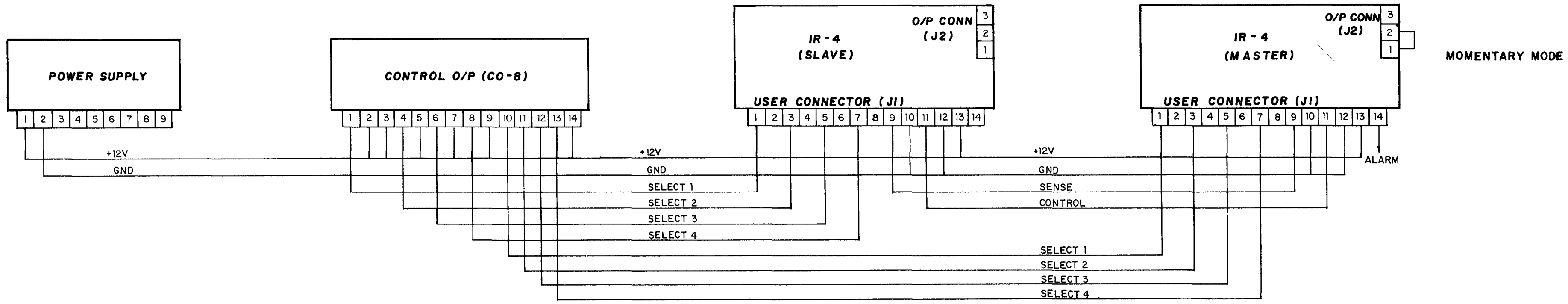


FIGURE 5d

Figure 5. Wiring Examples of IR-4 in Various Configurations

2.5 ELECTRICAL CONNECTIONS

2.5.1 General

All electrical cables should be consistent with mounting location environment and should confirm to applicable electrical codes.

Use weatherproof cable entrance hardware and proper external housing for outdoor installation.

For approved fire and security installations, refer to applicable regulations such as NFPA72D or other local requirements. The relays are UL and CSA approved and the contact ratings given should not be exceeded.

WARNING
The relay outputs may be connected to line voltage and high currents. Always check that the line voltage supplies are SWITCHED OFF before connecting or disconnecting any output connections.

2.5.2 Protective Ground

Pin 4 of the output connector (J2) is the protective ground for the module and must be connected directly to a separate electrical ground, preferably a buried water pipe or any other direct earth ground.

2.6 RELAY ENERGIZING MODES

Each relay (K1 to K4) can be energized in one of three different modes:

2.6.1 Direct Mode

+12 V supplied by one of the DC-4, CO-4 or CO-8 relays, and the ground of the relay is connected to the MRU PLUS ground on the same module.

2.6.2 JU2 Connected

a. Select and Actuate Mode; The ACTUATE is grounded by a second output relay after +12 V has been supplied to one or more of the SELECT inputs.

b. Select Only (Momentary); The ACTUATE is grounded all the time and only one relay at a time should be energized. +12 V is supplied by one of the DC-4, CO-4 or CO-8 relays and IR-4 relay is energized.

2.6.3 JU2 Not Connected

a. Select and Actuate Mode (J2 pin 3 connected to pin 2, position A); Same as 2.6.2a except that the safety circuit is operational, including the time-outs.

b. Select Only (J2, pin 1 connected to pin 2, position S); Same as 2.6.2b except that the safety circuit is operational.

Refer to the Decoder and Four-and Eight-Control Outputs section of instruction manual 68P02928G55.

2.7 USER INPUT CONNECTIONS

User input connections are located on the user connector terminal strip (see Table 2. User Connector Connections).

2.8 OUTPUT CONNECTIONS

The output connections of the IR-4 module are located on the output connector terminal strip (see Table 3. Output Connector Connections).

Table 2. User Connector Connections

Connector J1 Pin No.	Function
1	SELECT 1
2	GND 1
3	SELECT 2
4	GND 2
5	SELECT 3
6	GND 3
7	SELECT 4
8	GND 4
9	SENSE
10	ACTUATE
11	CONTROL
12	COMMON GND
13	+12 V
14	ALARM

Table 3. Output Connector Connections

Connector J2 Pin No.	Relay	Function
1	----	Connect to pin 2 for momentary operation
2	----	Common for mode selection
3	----	Connect to pin 2 for select/actuate operation
4	----	PROT GND
5	K1	NC
6	K1	C
7	K1	NO
8	K2	NC
9	K2	C
10	K2	NO
11	K3	NC
12	K3	C
13	K3	NO
14	K4	NC
15	K4	C
16	K4	NO

3. THEORY OF OPERATION

3.1 FOUR RELAYS K1 TO K4
(Refer to the schematic diagram at the end of this section)

Each of the four relays K1 to K4 is powered by +12 V from the appropriate pins of the user connector (J1). The relay outputs C (common), NO (normally open) and NC (normally closed) are connected to the output connector (J2).

Each relay has three 350 V varistors (VZ1-VZ12) one between NC and C, one between C and PROT GND and one between C and NO.

A green LED (DS1-DS4) is connected across each relay coil and is visible when the latch door on the top of the module is raised. The LED will light when the relay coil is powered.

Diodes CR1-CR4 are connected to the ACTUATE via transistor (Q1) and fuse (F1). These diodes allow any relay (that already has external +12 V connected to it) to be momentarily powered by connecting ACTUATE to the external +12 V supply GND. The fuse protects the 12 V supply from a short circuit.

3.2 SAFETY CIRCUIT

Connecting +12 V to SELECT 1 input produces current in R10 via CR5 and R3. Similarly, connecting +12 V to any other SELECT will produce current in R10 via its appropriate diode and resistor.

The sum of these currents in R10 produces a voltage (V_S) which is proportional to the number of relays selected. V_S is compared against two voltages (V_1, V_2). V_2 is less than V_S when one relay is connected and V_1 is more than V_S when one relay is connected but less than V_S when two or more relays are connected.

Comparator (U1b) positive input is connected to V_2 and its negative input to V_S. If no relay is selected then V_S will be zero volts and output of U1 will be high. CR15 will conduct and charge up C2. The high state on C2 is fed to the positive input of U1c, the negative input being connected to V_1. Voltage on C2 is higher than V_1 so U1c output is high which turns on transistor (Q1) via R2.

When +12 V is connected to any SELECT input V_S is higher than V_2 so the output of (U1b) goes low turning off CR15. C2 begins to discharge to ground via R8. When the voltage on C2 has dropped below V_1, output of U1c goes low turning off Q1. This gives the 30 second select timeout.

The safety circuit will only work correctly if the same voltage source is used for powering the relays and the safety circuit (as shown in Figures 5b, 5c, and 5d).

When pin 3 of J2 is connected to pin 2 (position A), connecting ACTUATE to ground (via an external relay) starts C2 discharging to ground via R7, CR9 and R9. This gives the 5 second (actuate) timeout.

When pin 1 of J2 is connected to pin 2 (position S), ACTUATE is connected to ground continuously. When +12 V is connected to any SELECT input, U1b output goes low (as described above) discharging C2 to ground via R7, CR9 and R9, giving the 5 second (momentary) timeout.

When more than one relay is selected at one time, the output of U1a goes low because V_S is now higher than V_1, CR10 makes U1c output go low immediately turning off Q1.

V_1 is connected to U1a via R12 with C3 to ground. When power is first applied the U1a positive input will start at ground potential and increase as V_1 charges C3, this takes approximately 5 seconds. If any relay had been selected during this time, U1a output would still be low which would turn off Q1 via U1c.

NOTE

During power-up or when one of the timeouts has been exceeded or if more than one relay has been selected, U1c output is low and U1d output is high enabling the ALARM and turning on the red LED (DS5). The above function is not disabled when JU2 is connected.

JU5 disables the select timeout by connecting U1b negative input to ground so its output is always high.

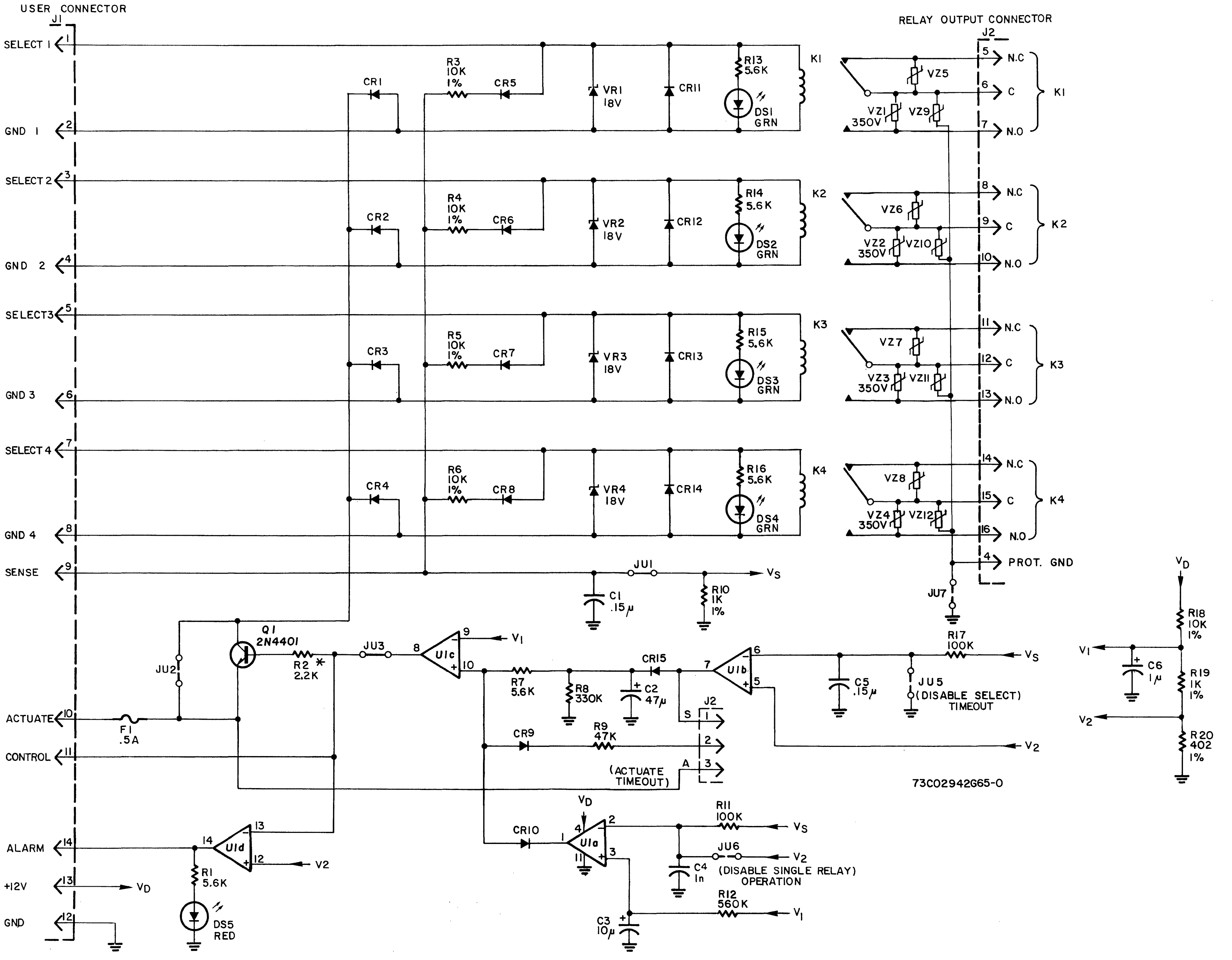
Since V_2 is always less than V_1 (except during power-up), connecting JU6 disables single relay operation by connecting V_2 to U1a negative input (in place of V_S).

JU2 provides an alternative path for the relay current to ACTUATE so that turning off Q1 will not affect relay operation.

3.3 OPERATION WITH TWO OR THREE MODULES

For two/three module operation, JU1 and JU3 are disconnected on the second/third module and SENSE (J1-9) in the two/three modules is connected. Any SELECT on the second/third module is connected via SENSE to R10 on the first module, so V_S on the first module is proportional to the number of relays selected on all modules.

Output of U1c on the first module is fed out via CONTROL (J1-11) to the second/third module's CONTROL to control Q1 on the second/third module.



* R2 IS 5.6K ON IR-4/2A (FLN4800A)

FLN4575A IR-4/10A Main Board
FLN4800A IR-4/2A Main Board
Schematic Diagram
May, 1987

parts lists

FLN4575A Main Board IR-4/10A — PL-0518-O

Reference Symbol	Motorola Part No.	Description
		Capacitor
C1	21-84008H03	.15 uF 50 V -20%+80%
C2	23-84538G06	47 uF 20 V 20%
C3	23-84762H03	10 uF 20 V 10%
C4	21-82187B14	1 nF 100 V 10%
C5	21-84008H03	.15 uF 50 V -20%+80%
C6	23-83441B29	1 uF 20 V 20%
		Diode
CR1 thru 4	48-91040030	1N4003
CR5 thru 8	48-11034A01	1N4148
CR9, CR10	48-84616A01	schottky
CR11 thru 14	48-91040030	1N4003
CR15	48-11034A01	1N4148
		LED
DS1 thru DS4	48-80159E11	green
DS5	48-80159E09	red
		Fuse
F1	65-02069C22	0.5A 250 V
		Connector
J1	28-08508G04	14-pin user connector
J2	31-02151C25	16-pin relay outputs
		Jumper
JU1 thru JU3	28-02218K12	2-pin jumper header
JU4	----	Not used
JU5, JU6	28-02218K12	2-pin jumper header
	29-02219K01	mini jumper; 5 used
		Relays
K1 thru K4	80-02630H08	12 V 15 A
		Transistor
Q1	48-02089C03	NPN, 2N4401
		Resistors
R1	06-11009C67	5.6k 1/4W 5%
R2	06-11009C57	2.2k 1/4W 5%
R3 thru R6	06-10621C91	10.0k 1/4W 1%
R7	06-11009C67	5.6k 1/4W 5%
R8	06-11009D10	330k 1/4W 5%
R9	06-11009C89	47k 1/4W 5%
R10	06-10621B94	1.00k 1/4W 1%
R11	06-11009C97	100k 1/4W 5%
R12	06-11009D16	560k 1/4W 5%
R13 thru R16	06-11009C67	5.6k 1/4W 5%
R17	06-11009C97	100k 1/4W 5%
R18	06-10621C91	10.0k 1/4W 1%
R19	06-10621B94	1.00k 1/4W 1%
R20	06-10621B56	402 1/4W 1%

FLN4575A Main Board — PL-0518-O

Reference Symbol	Motorola Part No.	Description
		Integrated Circuit
U1	51-83629M18	quad op amp
		Zener Diodes
VR1 thru VR4	48-83461E18	18 V
		Varistor
VZ1 thru VZ12	06-02597K02	350 V
	Non Referenced Items	
	42-02226C04	fuse holder; 2 used
	84-08330L01	printed circuit board

NOTE:
FLN4800A Main Board IR-4/2A is the same as above except for:

Reference Symbol	Motorola Part No.	Description
		Relay
K1 thru K4	80-02576K12	12 V 2 A
R2	06-11009C67	5.6k 1/4W 5%
	Non Referenced Item	
	84-08340L01	printed circuit board

FLN4630A Label Kit (IR-4/10A) — PL-0519-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	54-08124H13	address label IR-4/10A
	54-08635G22	front panel label IR-4/10A

FLN4801A Label Kit (IR-4/2A) — PL-0601-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	54-08124H14	address label IR-4/2A
	54-08635G23	front panel label IR-4/2A

FLN4629A Hardware Kit — PL-0520-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	03-00129675	lock screw 4-40 x 1/4"; 2 used
	31-08509G04	terminal with socket
	54-08125H01	user connector label

FLN4582A Housing — PL-0521-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	02-02427C01	lock nut 4 x 40
	03-08026H05	captive screw 8 x 32 7/8"; 2 used
	03-82210E15	captive screw; 2 used
	15-08513H01	housing base
	15-08656L01	housing cover
	15-08587G01	latch door
	22-02482C02	dowel pin

Note: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

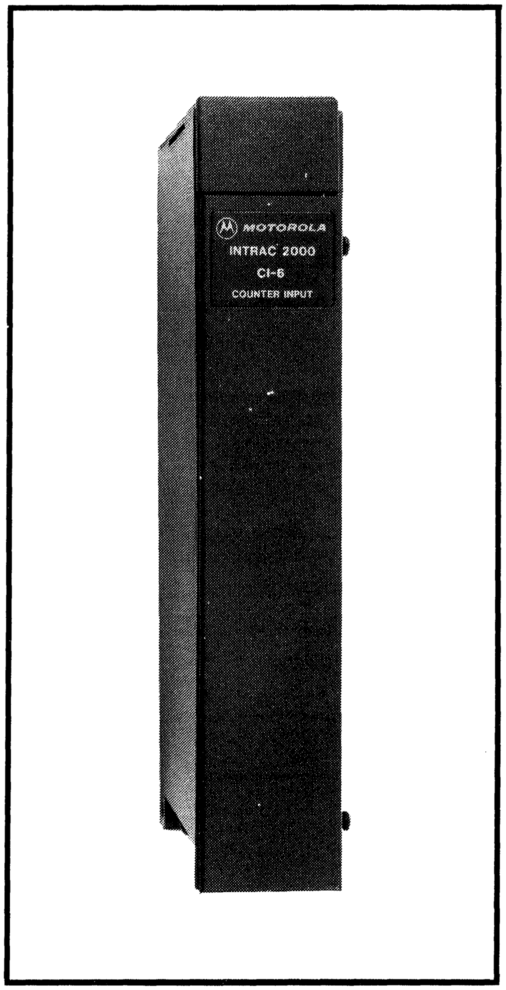
INTRAC 2000
Modular Remote Unit Plus
4-Interpose Relays

68P02946G90-O

MOTOROLA

INTRAC 2000®

Modular Remote Unit
Counter Input



Instruction Manual

68P02942G75-0

COMMERCIAL WARRANTY
(STANDARD)

Motorola radio communications products are warranted to be free from defects in material and workmanship for a period of ONE (1) YEAR, (except for crystals and channel elements which are warranted for a period of ten (10) years) from the date of shipment. Parts, including crystals and channel elements, will be replaced free of charge for the full warranty period but the labor to replace defective parts will only be provided for One Hundred-Twenty (120) days from the date of shipment. Thereafter purchaser must pay for the labor involved in repairing the product or replacing the parts at the prevailing rates together with any transportation charges to or from the place where warranty service is provided. This express warranty is extended by Motorola Communications and Electronics, Inc., 1301 E. Algonquin Road, Schaumburg, Illinois 60196, to the original purchaser only, and only to those purchasing for purpose of leasing or solely for commercial, industrial, or governmental use.

THIS WARRANTY IS GIVEN IN LIEU OF ALL OTHER WARRANTIES EXPRESS OR IMPLIED WHICH ARE SPECIFICALLY EXCLUDED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL MOTOROLA BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW.

In the event of a defect, malfunction or failure to conform to specifications established by seller, or if appropriate, to specifications accepted by Seller in writing, during the period shown, Motorola, at its option, will either repair or replace the product or refund the purchase price thereof, and such action on the part of Motorola shall be the full extent of Motorola's liability hereunder.

This warranty is void if:

a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage;
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

This warranty extends only to individual products, batteries are excluded, but carry their own separate limited warranty. Because each radio system is unique, Motorola disclaims liability for range, coverage, or operation of the system as a whole under this warranty except by a separate written agreement signed by an officer of Motorola.

Non-Motorola manufactured products are excluded from this warranty, but subject to the warranty provided by their manufacturers, a copy of which will be supplied to you on specific written request.

In order to obtain performance of this warranty, purchaser must contact its Motorola salesperson or Motorola at the address first above shown, attention Quality Assurance Department.

This warranty applies only within the United States.

EPS-27734-O

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EPS-34440-B

MOTOROLA INC.
Communications
Sector

INTRAC 2000®
Modular Remote Unit
Counter Input

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FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar equipment. The information it contains is current as of the printing date. Subsequent engineering changes are described in supplementary Instruction Manual Revisions (IMRs) issued as needed. The applicable schematic diagram is updated and the changes are described in a revision column printed either on the diagram or next to the corresponding parts list.

2. SERVICE

The Motorola National Service Organization offers one of the finest nationwide installation and maintenance programs available to communications equipment users. This organization comprises approximately 900 Motorola Service Stations located throughout the United States. Each Service Station is independently owned and operated, is staffed by one or more trained, FCC-licensed technicians, and is specially selected and authorized by Motorola.

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National Service Manager
Motorola Communications and Electronics Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

3. MODEL AND KIT IDENTIFICATION

Every Motorola product is specifically identified by an overall model number printed on the nameplate. In addition, the assemblies and kits comprising the product usually have kit model numbers stamped on them.

4. REPLACEMENT PARTS ORDERING

Motorola maintains a **factory parts center** and several **area parts centers** located throughout the United States. These facilities are equipped to process parts orders, identify part numbers, and otherwise assist in the maintenance and repair of Motorola Communications Group products. The addresses of these parts centers are listed on the following page.

Orders for crystals, channel elements, active filters, PROMs, code plugs, and resonant reeds should be and for instruction manuals should be sent to the nearest **area parts center.**

All orders for replacement parts or equipment information should include the complete identification number. This requirement applies to all components, kits and chassis. If the component part number is not known, the order should include the number of the chassis or kit which uses it, and a description of the desired component sufficient to identify it.

Orders for crystals and channel elements should specify the crystal or channel element type number, crystal and carrier frequencies, and the model number of the chassis using the part.

Orders for active filters, PROMs, code plugs, and "Vibrasender" and "Vibrasponder" resonant reeds, should specify type number and frequency, and should identify the owner/operator of the communications system utilizing these items.

5. ADDRESSES

5.1 AREA PARTS CENTERS

5.1.1 U.S. Orders

Western Area Parts
1170 Chess Drive, Foster City
San Mateo, California 94404
Telephone: 415-349-3111
TWX: 910-375-3877

Midwest Area Parts
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-7322
TWX: 910-693-0869

Parkway Drive
Hanover, Maryland 20176
Telephone: 301-796-8600
TWX: 710-862-1941

East Central Area Parts
12995 Snow Road
Parma, Ohio 44130
Telephone: 216-267-2210
TWX: 810-421-8845

Eastern Area Parts
85 Harristown Road
Glen Rock, New Jersey 07452
Telephones: 201-447-4000
TWX: 710-988-5602

Pacific Southwestern Area Parts
P.O. Box 85036
San Diego, California 92138
Telephone: 714-578-2222
TWX: 910-335-1634

Gulf States Area Parts
8550 Katy Freeway, Suite 128
Houston, Texas 77024
Telephone: 713-932-8955

Southwestern Area Parts
P.O. Box 34290
3320 Belt Line Road
Dallas, Texas 75234
Telephone: 214-241-2151
TWX: 910-860-5505

Southeastern Area Parts
P.O. Box 368
Decatur, Georgia 30031
Telephone: 504-981-9800
TWX: 810-766-0876

5.1.2 Canadian Orders

Motorola Ltd.
National Parts Department
3125 Steeles Avenue
E. Willowdale, Ontario M2H 2H6
Telephone: 416-499-1441
TWX: 610-492-2713
Telex: 065-25191

5.1.3 All Other Countries

Motorola Inc., or
Motorola Americas, Inc.
International Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
U.S.A.
Telephone: 312-576-6492
TWX: 910-693-0869
Telex: 722443 or 722424
Cable: MOTOL PARTS

5.2 FACTORY PARTS CENTER

5.2.1 Mail Orders

Motorola, Inc.
Component Products Sales and Service
P.O. Box 66191
O'Hare International Airport
Chicago, Illinois 60666

5.2.2 Other Correspondence

Motorola, Inc.
Component Products Sales and Service
2553 N. Edgington Street
Franklin Park, Illinois 60131

5.3 GENERAL OFFICES

Motorola Communications and Electronics Inc.
Communications Group Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-3900

KIT BREAKDOWN

FRN1657A Counter Input Module (CI-6)

FLN4623A	Main Board
FLN5720A	Main Board Hardware
FLN4347A	Modular Housing
FLN4624A	EPROM Kit
FLN4625A	Label Kit

PERFORMANCE SPECIFICATIONS

GENERAL

Input Voltage	11-15 V dc through the MRU bus.
Current Consumption	9 mA
Operating Temperature	-30°C to +60°C.
Relative Humidity	0-90% without condensation.
Weight	13.6 oz. (380.6 gr)
Dimensions	1.6" X 8.3" X 3.7" (W x H x D) 40.64 X 210.82 X 93.98mm Height with open door 11.6".
Housing	Thermo-plastic module.
Surge Protection	IEEE 472, 3kV 600 V, 25 uF capacitor discharge

INPUTS

Connections	Screw type terminal strip.
Electrical Definition	12 inputs, dry contact close <3k ohm (.2 mA sink current) open >40k ohm
Number of Function Inputs	6
Number of Status Inputs	4 (6 maximum with 4 Function Inputs)
FREEZE/RUN Input	Active with all functions, common basis with back-indication, 45 msec minimum pulse
FREEZE & RESET/RUN Input	Active on counters (pulse, run time) with back-indication, 45 msec minimum pulse

FUNCTIONS

COUNTER Category:
Data format 0 to 999
with overflow 1023

Pulse Counter	:1 prescaller :1000 prescaller 4.5 msec minimum pulse
Run Time Counter	Gate input - run/stop, minutes with 4.5 msec internal resolution

ANALOG Category: Data format -500 to +500; with overflow +511; underflow -512	
Pulse Rate	10 Hz range, ±.01 Hz resolution time response: 3.2 s to 3.2% accuracy 100 s to .1% accuracy no underflow indication
Pulse Duration	15 s and 5 s cycles 22.5 msec noise filter

OUTPUT DATA

Report to MRU Encoder	Activated by any of the following: 1. Predetermined change of value expressed in percentage of full scale (Delta) - pulse counter 70% - runtime counter 70% - pulse rate 25% - pulse duration 10% - status - every COS 2. Interrogation from central station 3. Local TEST activation, and power-up
Mask Option	Active with functions on common basis, to eliminate initiation of transmission
Resolution	10 bits ± lsb/25 ppm
Groups	Functions: C to H Status: B (with NOT USED option)
Parameters	On PC board, 16 DIP switches define: function per group function mask option status deactivation
Factory Default	Groups C to H NOT USED, group B status.

MOTOROLA INC.
Communications Sector

SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.
2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.
3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.
5. Use only a grounded soldering iron.
6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

   WARNING

   If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.

MOTOROLA INC.
Communications Sector

GENERAL DESCRIPTION

1. GENERAL DESCRIPTION

The Counter Input (CI-6) is an expansion module providing additional input capacity to the Modular Remote Unit (MRU) family of products.

The CI-6 provides up to six Function Inputs (FI) with common freeze and reset capabilities and four general purpose Status Inputs (SI).

A specific function is assigned (by the user) to each FI. A maximum of three different functions may be selected at one time.

The functions available are divided into two categories (counter and analog as follows (see Figure 1):

Counter:
- pulse counter (three types)
- run time counter

Analog:
- pulse rate
- pulse duration (two types)

The selection of the different functions is made through 16 DIP switches (located on the printed circuit board) for on-site flexible definition.

The freeze and reset capabilities are provided as two additional inputs that may be controlled locally or by control message from the central station via the MRU control outputs (relays).

The CI-6 receives the pulses in the inputs and transfers the data to the Encoder (ES-8) module via the MRU internal bus. The ES-8 will in turn transmit the data to the central station.

The CI-6 will initiate transmission in one of the four following conditions:

a. Interrogation from the central station.

b. Predetermined change of the computed data (Delta).

c. Transmission of current value of all functions and status when pressing the "TEST" button.

d. Transmission of "overflow" data in all the function groups in use, about 6 seconds after power up.

The function data is transmitted as 10 bits on groups C to H of the INTRAC 2000 word format. The four additional general purpose Status Inputs (SI) will be transmitted on group B. (Up to six SI can be used if only four FI are in use).

2. FUNCTIONS

2.1 GENERAL

The CI-6 provides four types of discrete functions that are divided into two categories:

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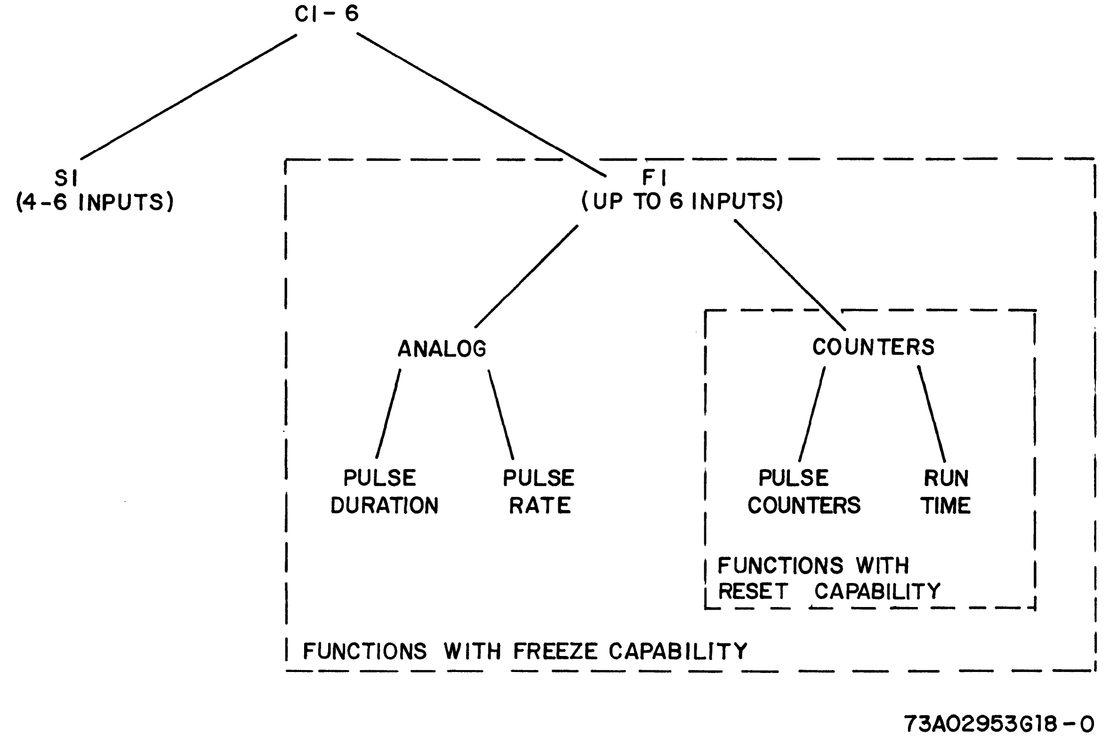


Figure 1. CI-6 Functional Diagram

- Counter Category: pulse counter, run time. The transmitted data is 0-999; overflow is 1023 and occurs whenever there are 1000 counts or more without transmission.

- Analog Category: pulse rate (frequency), pulse duration. The transmitted data format is -500 to +500; overflow/underflow is +511/ -512 respectively and occurs whenever out of range data is measured at the input.

Each function initiates transmission upon a predetermined change of value; this is named the DELTA parameter. It is possible to MASK the functions by a DIP switch in order to eliminate transmission by contention (DELTA=infinity).

The FI are designated FI-C to FI-H according to the transmitted groups.

NOTE

Each of the six FI uses one group for transmission (groups C-H) and it is designated according to the transmitted group (eg., input FI-C means function input transmitted on group C).

It is possible to define a FI as NOT USED which means that the respective input is not used as a function and its group is not used by the module. (This group may be used by other modules for Status Expansion, Analog Input etc.)

The predefined functions are listed in Table 1.

Table 1. Predefined Functions

Functions	Description	Delta
NOT USED	(the specific group/input is not used as a function).	
RUN TIME COUNTER	Minutes	70% DELTA
COUNTER:1	Pulse counter prescaller 1	70% DELTA
COUNTER:1	W/O overflow, always masked	Infinite Delta
COUNTER:1000	Pulse counter prescaller 1000	70% DELTA
PULSE DURATION	3/15	10% DELTA
PULSE DURATION	1/5	10% DELTA
PULSE RATE	10Hz max	25% DELTA

Note: Other functions, with different prescallers/ranges/delta and 2 input junctions (to eliminate bouncing & noise) are available and may be ordered as special products. Refer to the Special Products section for detailed information.

2.2 COUNTER Category (Pulse Counter, Run Time Counter)

These functions are count functions (integration); the output is the number of counts from 0 to 999 and the counting is cyclic modulo 1000, ie., 1, 2... 998, 999, 0, 1, 2... the values 1000 to 1022 are never transmitted.

The value 1023 represents overflow and occurs if 1000 counts are counted without a transmission. The importance of the Delta is usually not in the immediate transmission, but to eliminate overflow; therefore, Delta is set up to 70%. Overflow may occur only when the module cannot initiate a transmission, ie., the counter is masked (Delta is infinite) or if a long freeze is executed.

During an overflow condition, the internal counters continue to count; and during the following transmission (after the overflow condition was transmitted), the current value will be transmitted and the result updated. Therefore, if the counter is masked, it should be interrogated twice in order to update the value after overflow has occurred. If overflow occurs during freeze execution, (Freeze/Run input or Freeze & Reset/Run input is closed to GND) the module will transmit the overflow indication (1023) after the Run operation, and the current value immediately after that.

2.2.1 Pulse Counter

Three predefined pulse counters are available:

a.	Prescaler 1	Delta = 70%
b.	Prescaler 1 (see note)	w/o overflow and masked (never initiates transmission)
c.	Prescaler 1000	Delta = 70%

The physical pulses (open-to-close transition) at the input are divided by the prescaller to create one count (the least significant bit) of the transmitted data.

Note that the response time of the counters, and the pulse rate function, is very short; therefore, spikes and noise pulses longer than .1 msec may increment the counter. To overcome noise and spike problems, use the Input Protection (IP-8) module. To overcome bouncing problems use a 2-input function available as a special product.

Time response - pulses longer than 4.5 msec are always counted; pulses shorter than .1 msec are never counted. Pulses between .1 and 4.5 msec may be ignored.

NOTE

The predefined pulse counters with 1, 1000 prescallers may be used together to create a six-digit pulse counter. The transmitted 20 bit data will be in two groups (consult product group for details).

2.2.2 Run Time Counter

The Run Time Counter measures the time a device or a process is active with 1-minute resolution of transmitted data. The maximum measurable time without transmission is 999 minutes (16 hours and 39 minutes).

The physical input to the module is the gate for the time counter. As long as the input is closed to GND, the result is incremented every 1 minute (the internal time accumulation is of 4.5 msec resolution).

2.3 ANALOG CATEGORY (Pulse Rate, Pulse Duration)

The analog functions are instantaneous (analog) measurements and include pulse rate (frequency) and pulse duration.

The output format of the analog functions is from -500 to +500 (two's complement). The values +501 to +510 are transmitted as over-the-range values but are precise; the value +511 is overflow. The values -501 to -511 are transmitted on the pulse duration function as under-the-range values but are precise. The value -512 is transmitted on the pulse duration function as underflow.

2.3.1 Pulse Rate 10 Hz (frequency-pulses/time)

This function counts the number of pulses in a 100-second interval (window). The predefined Delta parameter for this function is 25%.

The frequency range is 0 to 10 Hz, measured by 1000 counts (transmitted value -500 to 500) i.e., accuracy of 0.01 Hz.

Transmitted value =
frequency (Hz) X 100 - 500

$$\text{Frequency(Hz)} = \frac{(\text{Transmitted Value} + 500)}{100}$$

The function uses a second short window of 3 second duration in order to track fast changes. It will detect fast changes and give a result of 3.2% accuracy. The 0.1% accuracy will be the steady state result.

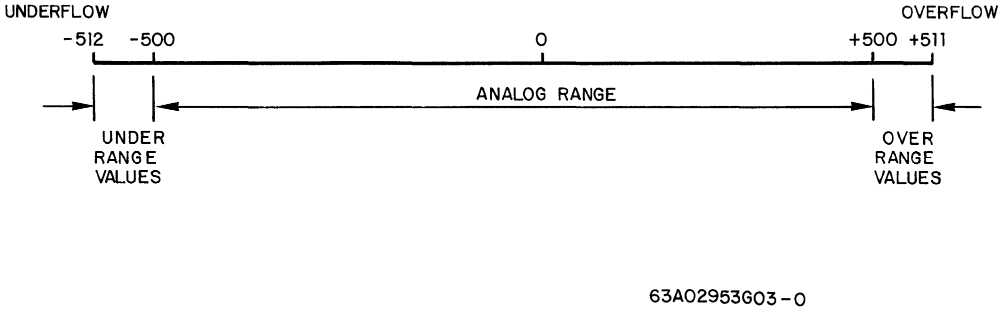


Figure 2. Analog Range

LEGEND:

transmitted value:

-500=less than 0.01Hz

+500=10Hz, full scale

+501 to +510=10.01 Hz to 10.1Hz (the over-the-range value)

+511=overflow (more than 10.1 Hz).

Time Response - pulses longer than 4.5 msec are always recognized pulses; shorter than .1 msec are never recognized. Pulses between .1 to 4.5 msec may be ignored (lower frequency).

2.3.2 Pulse Duration

This function measures the time when the contact (at the input) is closed in relation to a constant time interval.

There are two types of pulses suitable for standard level measurement sensors:

a. Type 3/15 pulse, a 15 sec cycle
b. Type 1/5 pulse, a 5 sec cycle.
(Refer to Figure 3. Formulas and Table 2. Pulse Duration Examples).

Time response - pulses longer than 22.5 msec are always counted, pulses shorter than 22.5 msec are always filtered (ignored).

a. Type 3/15 pulse, a 15 second cycle.

$$\text{Transmitted value} = \frac{1000}{9} \times (\text{close duration [sec]} - 3) - 500$$

$$\text{Close Duration [seconds]} = \frac{9}{1000} \times \text{Transmitted value} + 7.5$$

b. Type 1/5 pulse, a 5 seconds cycle

$$\text{Transmitted Value} = \frac{1000}{3} \times (\text{close duration [sec]} - 1) - 500$$

$$\text{Close Duration [seconds]} = \frac{3}{1000} \times \text{Transmitted value} + 2.5$$

Figure 3. Formulas

Table 2. Pulse Duration Examples

Example	Pulse (Close) Duration Time (sec)		Transmitted Value
	Type 1/5	Type 3/15	
1	0	0	-512 (underflow)
2	1	3	-500
3	2.5	7.5	0
4	4	12	+500
5	5	15	+511 (overflow)

NOTE: If the cycle is not of 5 or 15-second duration and less than 18 seconds, the function will give a result according to the formulas above. If the closed/open pulse is of a duration longer than 18 seconds, a close contact pulse will give overflow and an open contact pulse will give underflow.

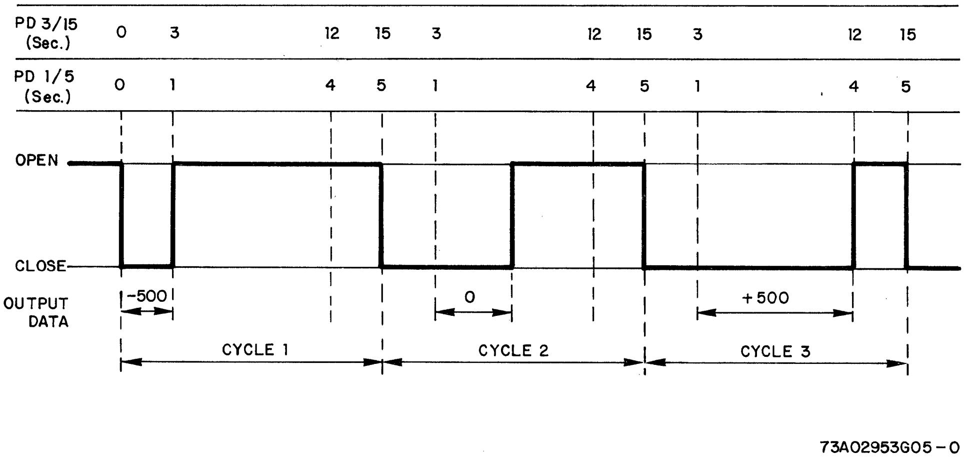


Figure 4. Pulse Duration Function

3. FUNCTIONAL DESCRIPTION

3.1 DELTA MECHANISM

The Delta limit mechanism is provided in order to initiate a transmission upon a predefined change (Delta) in the computed value, expressed in percentages of the full scale. The change is measured from the last transmitted value (absolute change). There is a specific Delta assigned to each type of function according to its application (refer to Table 1. Predefined Functions above).

An exception to the Delta limit mechanism is the analog overflow/underflow condition, which will be transmitted regardless of the Delta limit (unless the Delta is infinity).

In order to eliminate Delta transmission by the module, the functions may be masked (S2-7=open) so that the function value can only be interrogated.

3.2 FREEZE/RUN, FREEZE & RESET/RUN INPUTS

The CI-6 functions may be controlled by 2 additional inputs: FREEZE/RUN and FREEZE & RESET/RUN. Activation is implemented by connecting the input to a ground for any period of time longer than 45 msec. Remote activation may be implemented by connecting the input to a relay of the control module and execution of control operation from the central station. A group that is frozen will not initiate transmission upon a Delta crossing. Upon interrogation it will transmit the same value (the frozen value).

Back Indication - the module can report Freeze/Run or Freeze & Reset/Run states if the status inputs are active (S2-8=close). The Freeze/Run, Freeze & Reset/Run input states are logically related to status inputs 5 and 6 in group B that indicate back indication of the activation (refer to Figure 6. Input/Output Transfer of Information).

FREEZE/RUN - active for all functions. If this input is connected to GND, the last values of the functions are frozen (do not change). The internal function values are computed and the transmitted value will be updated as soon as the freeze is deactivated (re-opened).

The Freeze/Run state is indicated by status input 5 of group B which is masked but can be interrogated.

FREEZE & RESET/RUN - active on counters only (pulse counter and run time counter). The moment this input is closed to GND the following occurs: first, the value to be transmitted is frozen. Second, the counters are reset and begin to count from zero.

The transmitted value of the counters is frozen (does not change) until the terminal is re-opened, then it is updated with the result of the new counting. (Initiation of transmission depends on the specific Delta parameter that will assume value 0 as the last transmitted value).

The Freeze & Reset state is indicated by Status Input 6 of group B which is masked but can be interrogated.

NOTE

> A reset operation may be implemented by connecting the Freeze & Reset input to a momentary relay of the Decoder module (the Freeze operation is very short and is a non-destructive operation).

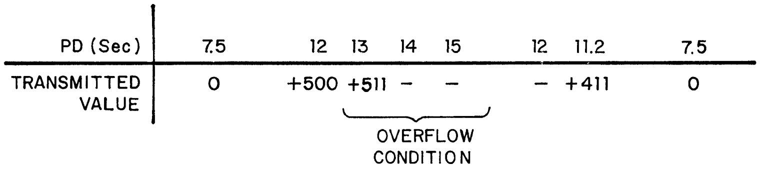
3.3 OVERFLOW/UNDERFLOW CONDITIONS

(Refer to Figure 5. Overflow/Underflow)

Overflow/underflow conditions are indicated as the maximum/minimum scale of the transmitted data and have a different meaning for counter and analog categories:

Table 3. Overflow/Underflow Conditions

Function	Overflow	Underflow
Run Time Counter	1023 >1000 counts without Tx	-------
Counter, (prescallers 1, 1000)	1023 >1000 counts without Tx	
Pulse Duration, 3/15	+511 >=12.099 second	-512=<2.892 second
Pulse Duration, 1/5	+511 >=4.033 second	-512=0.964 second
Pulse Rate, 10 Hz range	+511 >=10.1 Hz	-------



PD 3/15 FUNCTION , DELTA = 10%

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Figure 5. Overflow/Underflow Conditions

Counter (pulse counter, run time) - no underflow condition. The value 1023 is overflow and occurs if 1000 counts are counted without transmission. Overflow may occur only when the module cannot initiate transmission (when the counter is masked (Delta is infinite) or if a long freeze is executed).

Analog (pulse rate, pulse duration) - overflow condition is transmitted as value +511 underflow condition is transmitted as value -512. Pulse rate function does not have underflow condition (0 frequency is -500). Overflow/underflow condition is whenever the value computed by the function is out of range:
overflow - more than +510
underflow - less than -511.

If an overflow/underflow condition occurs it is transmitted once regardless of the Delta condition at that time. The function will not initiate transmission unless the computed value is appreciably beyond both ends (over or under the Delta limit).

Overflow/Underflow - after power-up the module will initiate transmission of overflow on all the function groups that are in use, this is an indication of system power-up.

3.4 STATUS INPUTS
(refer to Figure 6. Input/Output Transfer of Information)

The CI-6 module provides, in addition to the six function inputs, four general purpose status inputs that will initiate transmission with every change-of-state (COS). The physical inputs corresponding to function inputs for group G and for group H can be used as additional status inputs. Therefore, if groups G and H are not used as functions, they are available as general purpose status inputs. In such a case, there are six general purpose status inputs to the module and only four functions (on groups C to F).

Inputs status are transmitted on group B as 8-bit data. They can be deactivated by opening switch S2-8 on the module's printed circuit board. This feature may be used to take advantage of group B in a Status Input 8 module to obtain eight general purpose status.

If groups G and H are configured as functions, their input state is indicated by status bits 7 and 8 of group B ("1" is closed). This feature may be used, for example, together with the run time counter to indicate if the process is active at a particular moment (in addition to the run time function). The state itself is masked (will not initiate transmission when COS occurs but may be interrogated).

The FREEZE/RUN, FREEZE & RESET/RUN inputs back indication is transmitted on status bits 5 and 6 of group B accordingly ("1" is active). These status inputs are masked (will not initiate transmission).

3.5 OUTPUT GROUPS
(refer to Figure 6. Input/Output Transfer of Information)

The CI-6 module utilizes a maximum of seven out of the eight available input groups for one MRU. Group B is the status group (if selected). Groups C to H are the function groups; each of these groups may be selected as NOT USED and may be utilized by the user for an analog input or status input group in other modules.

Group B: 8-bit data, if status inputs are selected (S2-8=closed), otherwise it is ignored (does not exist).

Status bits 1-4:	General purpose status
Status bit 5:	FREEZE back indication
Status bit 6:	FREEZE & RESET back-indication

Status bit 7: General purpose status if the function is not assigned to group G. Input state of function on group G if the function is assigned to this group.

Status bit 8: General purpose status if function is not assigned to group H. Input state of function on group H if function is assigned to this group.

"1" is closed/active, "0" is open/not active.

Groups C to H: bits 1 to 10 represent the function values.

Counter category functions: 0-1000 format.

Analog category functions: -500 to +500 format.

3.6 PARAMETERS

The CI-6 parameters are defined via DIP switches. Three basic actions can be defined as follows:

a. Assign the desired function for each one of the groups C to H (including the NOT USED option)

b. Mask or unmask the functions

c. Activate or deactivate the status group.

All details on parameter setting etc. are described in the Installation section of this manual.

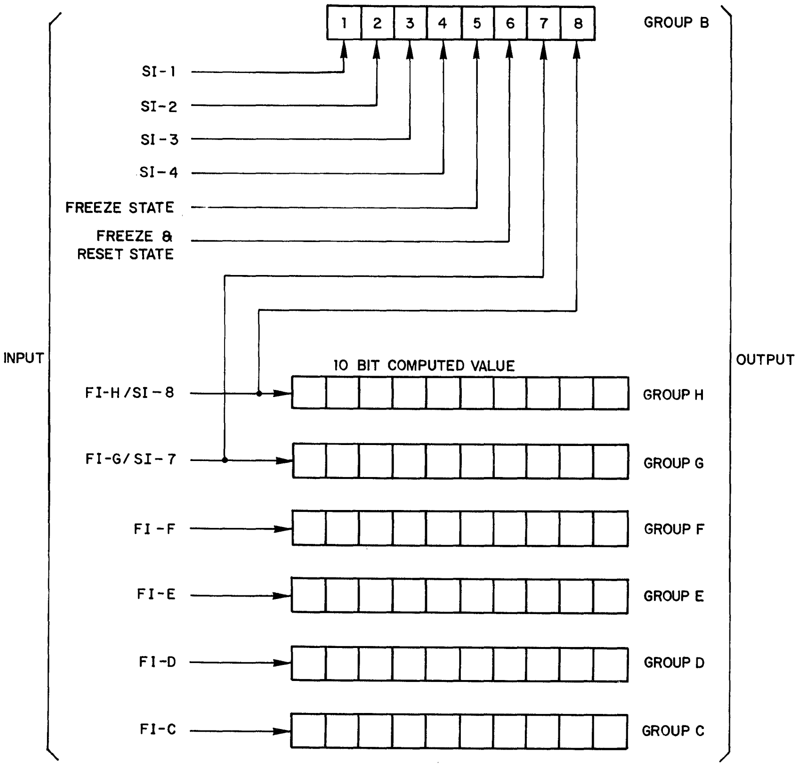

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Figure 6. Input/Output Transfer of Information

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INSTALLATION

1. PRELIMINARY

Carefully inspect the CI-6 module immediately upon receipt and notify the shipper of any damage that has ocurred in transit. The installation procedure consists of mounting the housing, if ordered as add-on, and making the necessary external and internal electrical connections. For mounting details refer to Figure 1. Housing Detail.

2. DISASSEMBLY

(Refer to Figure 2. Disassembly)

Step 1. Lift the latch door located at the top of the housing.

Step 2. Disconnect the MRU bus flat cable.

Step 3. Loosen the two captive screws which hold the module to the mounting plate (not visible).

Step 4. Loosen the two captive screws on the right panel of the CI-6 module housing.

Step 5. Assure that the latch door is open.

Step 6. Gently separate the two sides, exposing the printed circuit board (PCB).

3. DIP SWITCHES/MODULE DEFINITION

To access the DIP switches follow steps 1, 2 and 3 above and set the DIP switches with a thin long object (such as a pencil) through the latch door above the bus connector (S1 is the first switch on the left).

3.1 GENERAL

NOTE

The CI-6 module will read the DIP switches only upon power-up or test activation.

The CI-6 module parameters are defined by 16 DIP switches located on the printed circuit board. The module is supplied by default with all the function groups selected as NOT USED (groups C to H do not exist).

The total number of input groups in the MRU is limited to eight where each of the following consume one group:

- 1 function of the CI-6 module
- 1 analog input of the AI-6 module
- 8 status of the ES-8, SI-8 or CI-6 module.

The MRU with CI-6 module and other input expansion modules is set by factory as follows:

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Module	# of Modules in MRU	Input Groups
ES-8	1	A status
CI-6	1	B status (C to H not used)
AI-6	1	H analog input (C to G not used)
SI-8	X	C to C+X-1

X = number of modules

In order to set up an MRU with the desired input capacity proceed as follows:

1. Adjust the AI-6 module parameters (if an AI-6 module is included in the MRU) according to the number of analog groups that are desired.

2. According to the groups in use in 1. above and the SI-8 groups that are set by factory (from group C and upward), assign the desired functions in the CI-6 to the groups left free.

3.2 CI-6 MODULE PARAMETERS

The DIP switches define three operations (refer to Table 7. DIP Switch Position at the end of this section):

a. Assign the desired function for each of the groups C to H (including the NOT USED function).

b. Mask or unmask the functions.

c. Activate or deactivate the status group.

Implementation of (a)

The functions available are listed in Table 1 (refer to the end of this chapter for tables).

The functions are organized in four applications; in each application there are three functions and the NOT USED option. Locate the application in Table 3. Applications (at the end of this section), which includes the desired functions. Once the application is chosen, only those functions in the specific application are available (other function combinations may be ordered as SP. (Refer to Special Products section for detailed information).

Set S2-5, S2-6 to the desired application according to Table 3. Applications (at the end of this section).

Assign one of the three available function types, or the NOT USED option to each of the groups C to H. Refer to Table 4. Function Assignment at the end of this section.

Implementation of (b)

Open S2-7 in order to mask the functions (see Table 5 at the end of this chapter).

Implementation of (c)

Open S2-8 in order to deactivate the status group (see Table 6 at the end of this chapter.

After setting the DIP switches, reassemble the module, connect the flat cable and press the TEST pushbutton located near the bus connector (next to the latch door). Watch the self diagnostic LED, it should flash twice, stop and flash twice again. If it flashes any number of times refer to the Maintenance section, LED Indication, Detailed Diagnostic Table.

4. JUMPERS

JU1 - Watchdog Timer:
Connected - enabled, (normal operation)
Disconnected - disabled.

JU2 to JU7:
Fixed (should not be changed for normal operation).

5. MOUNTING

Mount the CI-6 module next to the other MRU modules with the two captive screws (included with the module), then connect the MRU bus flat cable to the bus connector of the CI-6 module.

The connection between the CI-6 and the MRU Encoder (ES-8) is via a 26 pin J2 on the CI-6 module. In order to insert the cable connector correctly to J2, the user must match the triangular sign on the male and female connectors. (The triangular sign on the cable connector is on the same side as the red painted wire on the cable.)

6. CONNECTIONS

6.1 EXTERNAL CONNECTIONS

All electrical cables should be consistent with mounting location environment and should conform to applicable electrical codes.

Use weatherproof cable entrance hardware and proper external housing for outdoor installation.

For approved fire and security installations, refer to applicable regulations such as NEPA 72D or other local requirements.

6.2 USER INPUT CONNECTIONS (Refer to Table 2. Physical Connections)

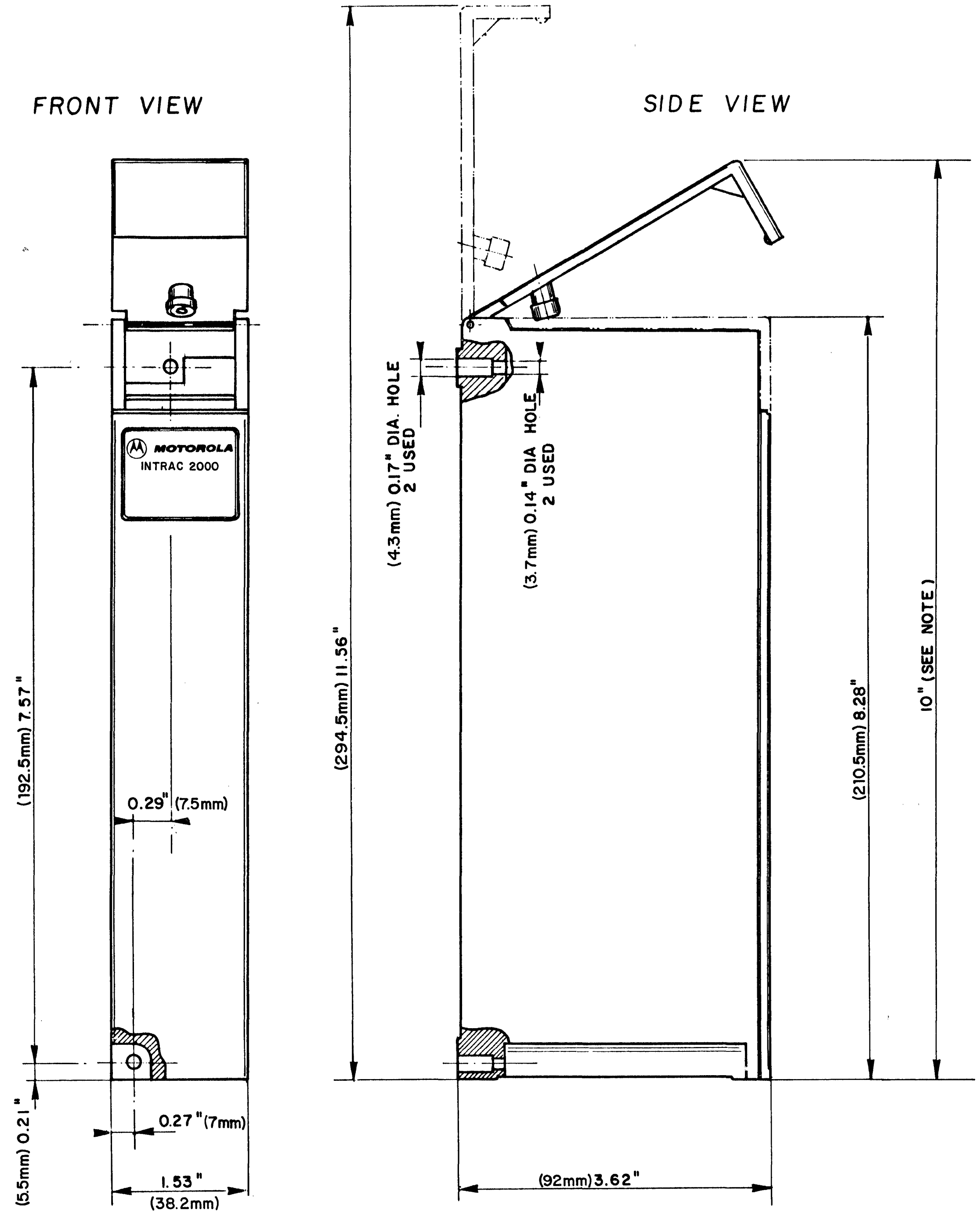
The twelve inputs are single-ended and are referenced to ground. The external circuits connected to these inputs should consist of dry contacts. The inputs recognize an external resistance of less than approximately 3k ohms as a closed circuit, and an external resistance greater than approximately 40k ohms as an open circuit.

The CI-6 supplies only 0.1 mA of current to the external contacts.

The inputs are located on the user connector terminal strip.

NOTE

The CI-6 circuit ground (terminals 7 and 12) are the common return terminal for the status inputs. To avoid undesirable ground loops, the input returns should be connected to one or both of these terminals and must not be grounded elsewhere.



NOTE

MINIMUM OPENING FOR REMOVING WIRE CONNECTOR.

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Figure 1. Housing Detail

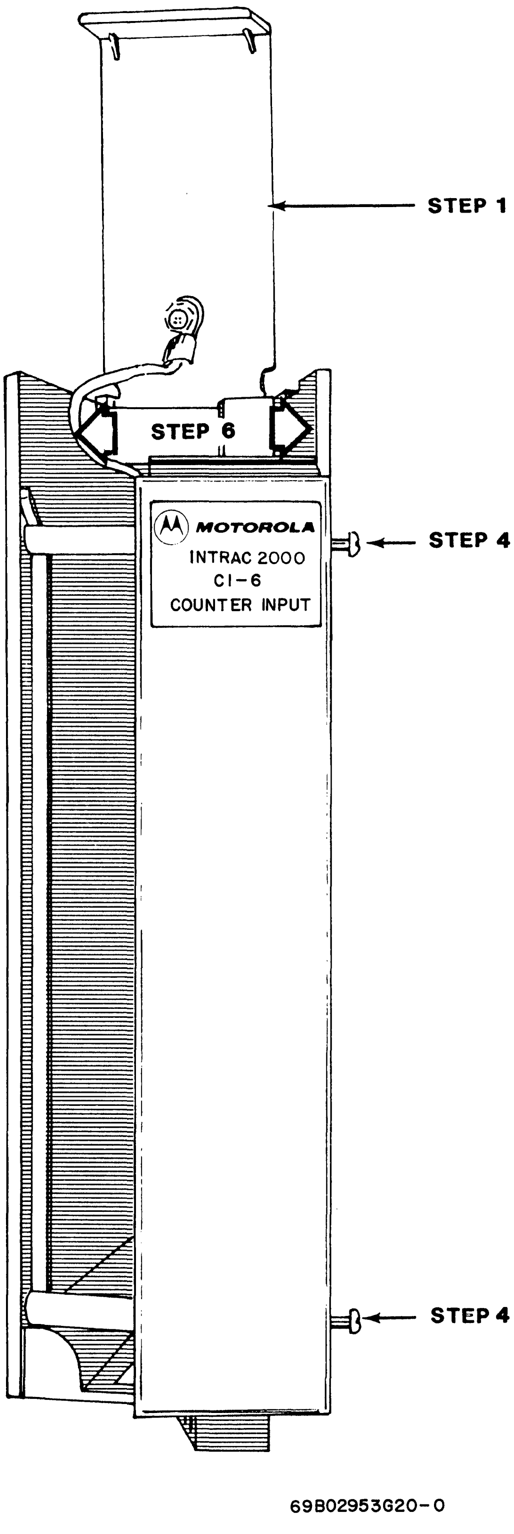

Figure 2. Disassembly

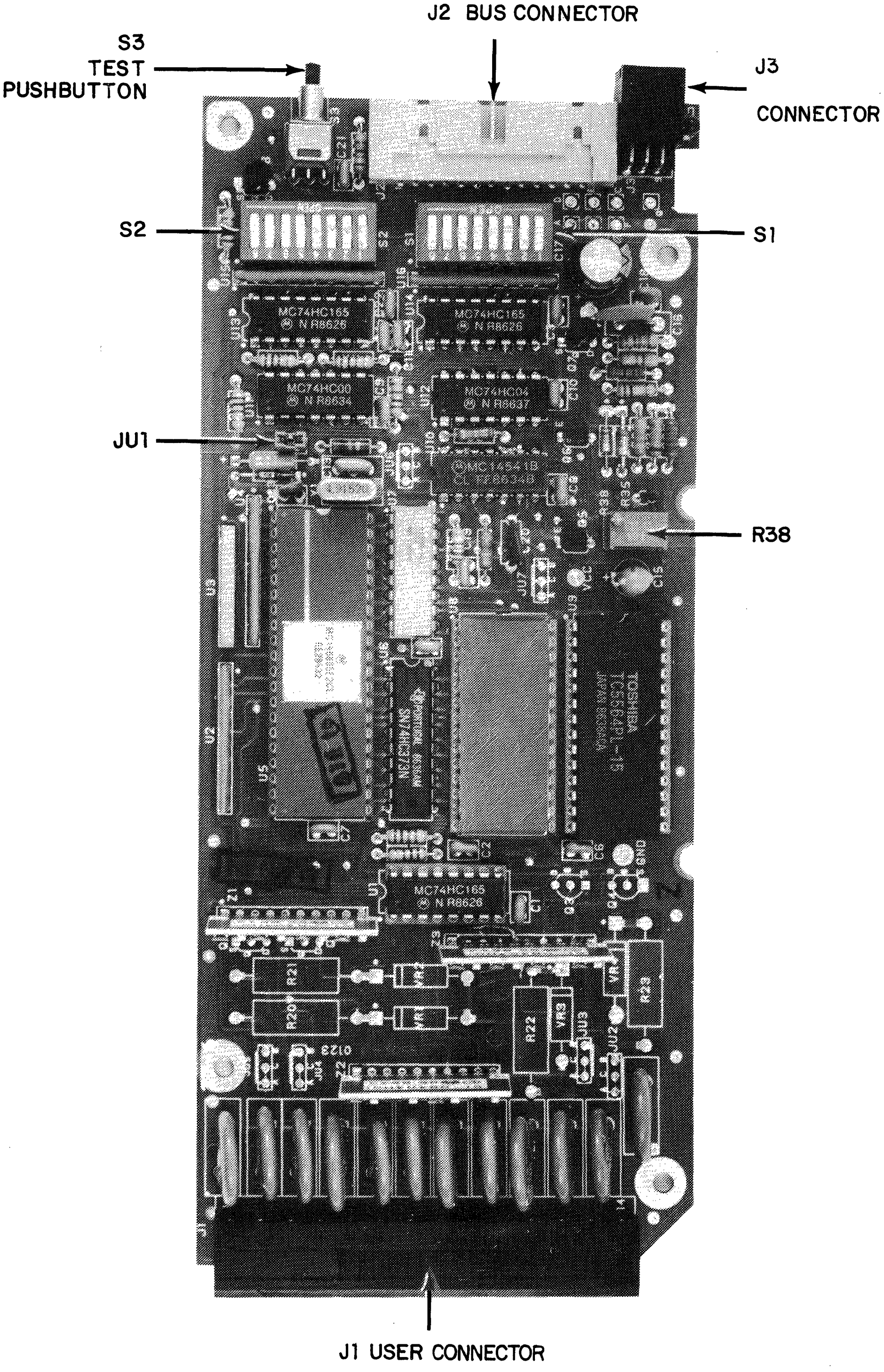

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Figure 3. Printed Circuit Board

Table 1. Functions

Functions	Description	Delta
NOT USED	(the specific group/input is not used as a function).	
RUN TIME COUNTER	Minutes	70% DELTA
COUNTER:1	Pulse counter prescaller 1	70% DELTA
COUNTER:1	W/O overflow, always masked	Infinite Delta
COUNTER:1000	Pulse counter prescaller 1000	70% DELTA
PULSE DURATION	3/15	10% DELTA
PULSE DURATION	1/5	10% DELTA
PULSE RATE	10Hz max	25% DELTA

Table 2. Physical Connections

J1 Input (Physical)	Function	Group
1	Function Input	C
2	Function Input	D
3	Status Input 1	B
4	Status Input 2	B
5	Status Input 3	B
6	Status Input 4	B
7	GND	
8	Freeze Control Input	All Functions
9	Freeze and Reset Input	All Counter Type Functions
10	Function Input	G (SI-7 on group B)
11	Function Input	H (SI-8 on group B)
12	GND	
13	Function Input	E
14	Function Input	F

Table 3. Application

Application	Switches	Function Types			
	S2-5 S2-6	0	1	2	3
0	Close close	Not used	Run time	Counter:1	Pulse rate (10 Hz max)
1	Open close	Not used	Pulse duration 3/15	Counter:1	Pulse rate (10 Hz max)
2	Close open	Not used	Pulse duration 1/5	Counter:1	Pulse rate (10 Hz max)
3	Open open	Not used	Run time	Counter:1 No Overflow	Counter:1000

Assign one of the three available function types to each of the groups C to H:

Table 4. Function Assignment

Group	Switches	Function Types			
		0	1	2	3
C	S1-1 S1-2	close close	open close	close open	open open
D	S1-3 S1-4	close close	open close	close open	open open
E	S1-5 S1-6	close close	open close	close open	open open
F	S1-7 S1-8	close close	open close	close open	open open
G	S2-3 S2-2	close close	open close	close open	open open
H	S2-3 S2-4	close close	open close	close open	open open

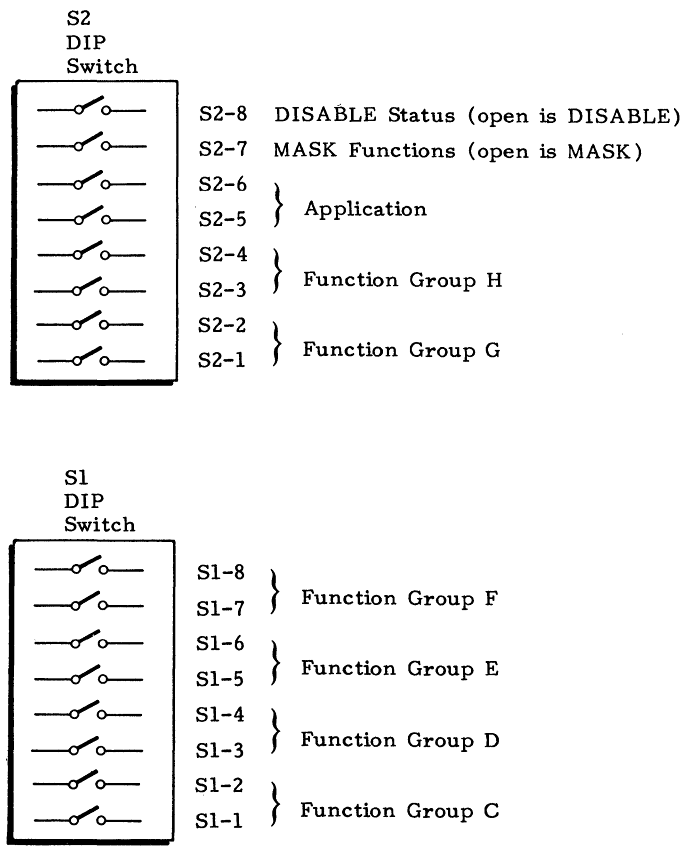
Table 5. Autonomous Transmission

Switch	Operation of Transmission
S2-7 Open	All functions are masked, transmission by response to interrogation or local test.
S2-7 Closed	Transmission also by crossing assigned Delta limit of each function.

Table 6. Status Input Disable

Switch	Description
S2-8 Open	Status inputs of CI-6 are disabled
S2-8 Closed	Status inputs of CI-6 are enabled and occupy group B.

Table 7. DIP Switch Position



LEGEND: "0"= close
"1"= open

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THEORY OF OPERATION

1. GENERAL

The Counter Input (CI-6) PC Board is based on the MC146805E2 CMOS microprocessor. It contains the following circuits:

- Processing Unit
- Input Sensing and Surge Protection
- 5 V Regulator
- Bus Interface
- Watchdog Timer
- External Connectors

2. CIRCUITS DESCRIPTION

2.1 PROCESSING UNIT

The processing unit consists of the MC146805E2 microprocessor (U5), EPROM (U8), address latch (U6), RAM (U9) and memory mapping (U11, U12, JU6 and JU7).

2.2 INPUT SENSING AND SURGE PROTECTION

Twelve dry-contact inputs are located on user connector J1. The protection circuit consists of varistors VZ1-VZ12 and hybrids Z1-Z3.

2.3 5 V REGULATOR

The purpose of the 5 V voltage regulator circuit is to regulate the input voltage to 5 V dc in order to supply proper voltage to the logic circuits. The regulator has a low standby current of 80 uA. The voltage output is temperature compensated and is accurate to better than ±5%. The regulator is current limited and prevents the CMOS logic from entering SCR mode by using a fold-back current limiter technique.

2.4 BUS INTERFACE

The bus interface consists of six lines which are connected to the I/O ports of the microprocessor through series protection resistors (U7) and pull-up resistors (U4), (see Table 1, Microprocessor Port Bus Connector).

Table 1. Microprocessor Port Bus Connector

Port	Function
PB6	READY
PB0	DATA
PB5	BUSY
IRQ	BUSY
PB4	CK
PB3	ADDR
PB7	BREQ

The bus provides two-way communication, to and from the CI-6.

a. The CI-6 receives messages when:

- The Decoder has received an interrogation message.

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- The test button on the Decoder is activated.

- The test function of the Encoder is activated.

- The Encoder periodic timer has finished its cycle.

b. The CI-6 requests transmission due to a COS or when the module test function is activated.

2.5 WATCHDOG TIMER

The watchdog timer circuit is used to prevent program runaway. It has an autonomous oscillator/timer (U10, R25, C19, R26). The circuit is designed to set its output approximately 3.5 sec. after being reset. If the time period elapses, U10 pin 8 will go low and a reset to the microprocessor will be generated.

Under normal conditions, the microprocessor periodically executes a code, which in turn, generates a reset pulse. The pulse resets the timer (U10 pin 6) through C20. In this case, U10 is normally high since it is reset by the microprocessor before the 3.5 sec. period expires. However, if the program runs away, there is a good chance that the microprocessor will not execute the short sequence of instructions that generate the reset pulse to the watchdog timer. The timer will continue to count freely and, when 3.5 sec. have elapsed, it will generate a reset pulse to the microprocessor. The microprocessor will then initiate a software reset to the system.

3. SAFETY FEATURES

The following safety features are incorporated in the CI-6 module:

a. Check sum of all constant parameters in the RAM every 9 seconds.

b. Parameter Restructuring

b.1 If a check-sum error occurs, all parameters will be restructured (from information in the DIP switches and EPROM) without affecting the values of the functions and status. Restructuring is performed by initiating a TEST so the CI-6 module will transmit all the function and status current values as well as flash the LED in accordance with the errors.

b.2 If the error occurs after restructuring the parameters, the module will go through the same procedure after a wait of half an hour.

c. Self Diagnostic - performing the following checks and flashing the LED accordingly (after power-on or pushing test button):

- bus communication
- micro hardware
- EPROM
- RAM
- data base overflow

d. Input Filter Software - to reduce bouncing and noise on the following inputs (they do not have to respond to fast signals):

- status 30 msec (average)
- freeze/run, freeze & reset/run, 45 msec
- pulse duration 22.5 msec.

e. Input Filters Hardware - .5 msec on all the twelve inputs with surge protection (varistor and zener diode).

f. Watchdog Timer - initiates hardware reset if program runaway occurs (current data is destroyed).

4. SOFTWARE DESCRIPTION

A timer interrupts the software every 4.5 msec, checks all the 12 inputs and advances their state to a 256 (12 bit) cyclic buffer. A free running scheduler schedules the tasks that handle functions, status, self diagnostic and bus communication.

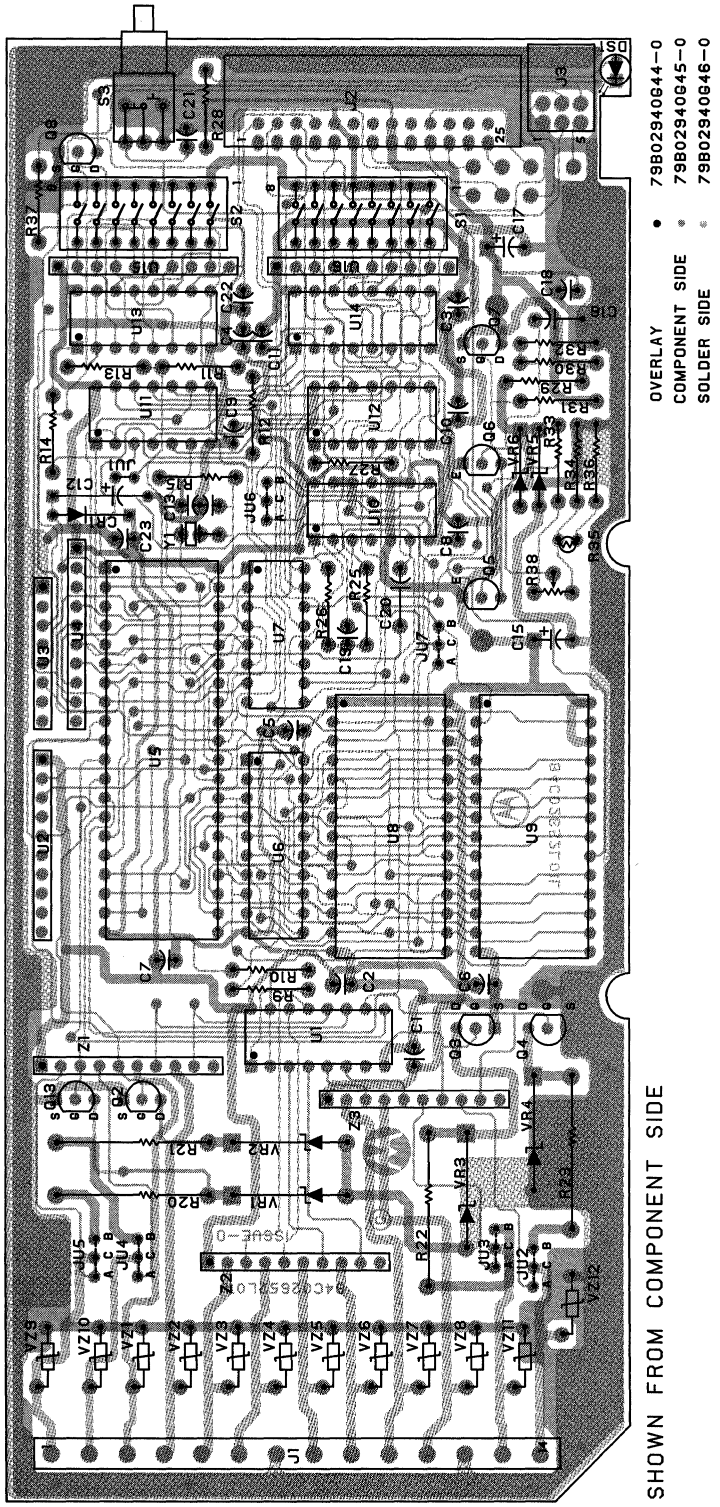
The function task pulls data from the buffer and computes the functions according to the module parameters set by the DIP switches; it compares the value to the delta parameter and sets a change-of-state (COS) flag if the delta has elapsed.

The status task pulls data from the buffer, calculates COS and sets the COS flag if needed.

If the COS flag is set, the bus communication task initiates bus communication and transfers the data to the ES-8 module. If the ES-8 module initiates bus communication and interrogates the CI-6 module, the bus communication task is responsible for transfer of data to the ES-8 module.

The diagnostic task checks the TEST pushbutton; if it is pressed, the diagnostic task initiates transmission of the current data, reads the DIP switches, structures the module parameters, and flashes the LED according to the errors detected during module operation.

Immediately after power-up the module flashes the LED according to the errors detected. If there are no errors the LED flashes twice, stops and flashes twice again. About six seconds after power-up the module initiates transmission of overflow data in all the function groups being used.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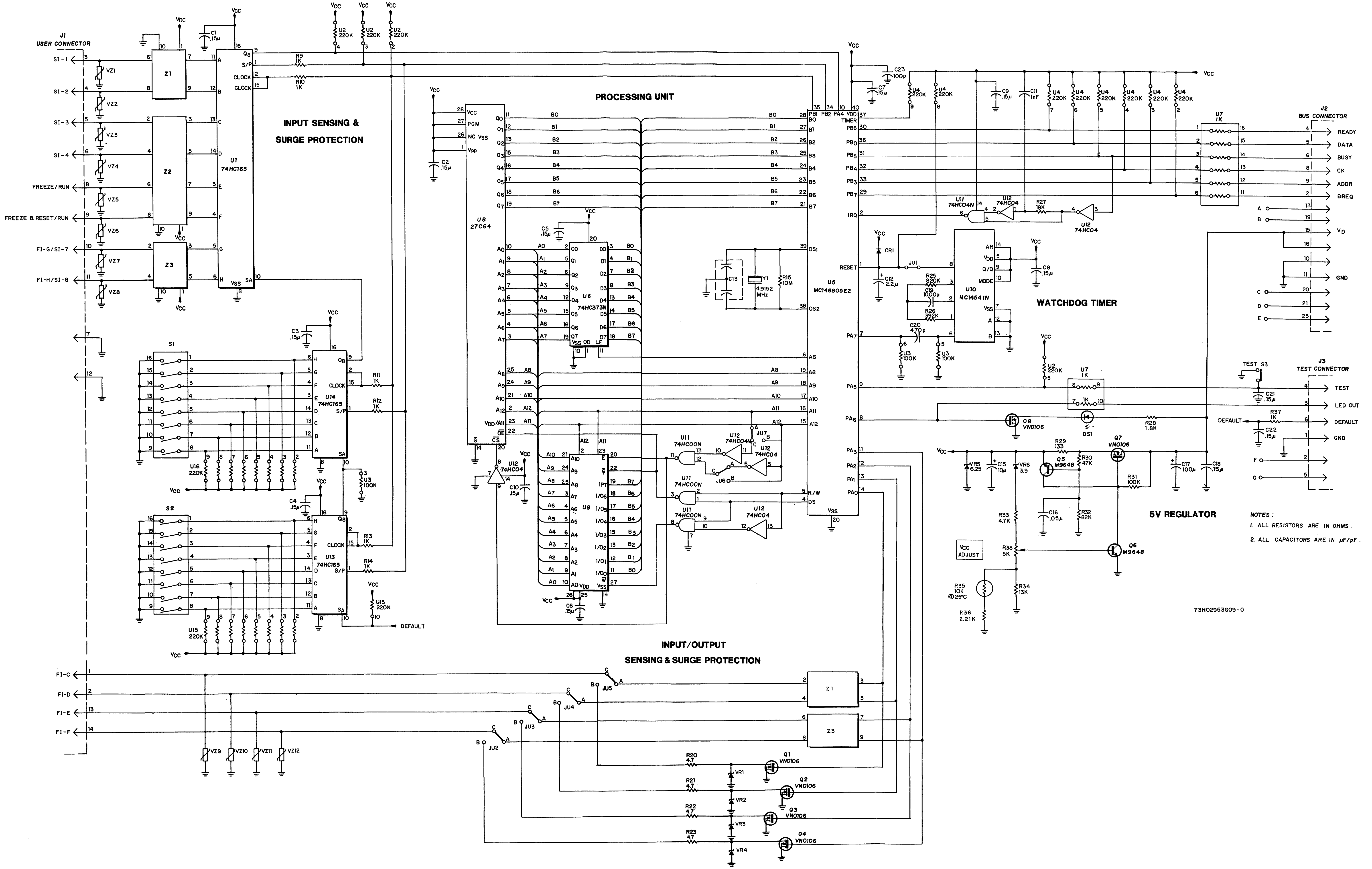
COMPONENT SIDE ● 79B02940G45-0
SOLDER SIDE ● 79B02940G46-0

FRN1657A Counter Input (CI-6)
Printed Circuit Board Detail
June, 1987



NOTES :
1. ALL RESISTORS ARE IN OHMS.
2. ALL CAPACITORS ARE IN μF/pF.

73H02953G09-0

FRN1657A Counter Input (CI-6)
Schematic Diagram
June, 1987

parts lists

FLN4623A CI-6 Main Board PL-0636-O

Reference Symbol	Motorola Part No.	Description
		Capacitor fixed: uF unless otherwise stated
C1 thru 10	21-84008H03	0.15
C11	21-83162H09	1 nF ±5% N150
C12	23-84762H04	2.2
C13	48-08565C02	part of Y1
C14	-----	Not used
C15	23-84538G10	10, 20 V
C16	21-82372C04	0.05 -20+80%, 25 V
C17	23-02166L06	100
C18	21-84008H03	0.15
C19	21-83162H09	1 nF ±5%
C20	21-82428B51	470 pF ±5%, 200 V
C21	21-84008H03	0.15
C22	21-84008H03	0.15
C23	21-05455G01	100 pF 50 V
		Diode (see note 1)
CR1	48-11034A01	Signal HO1
		LED
DS1	48-84404E03	Red LED
		Connector
J1	28-08508G04	14-pin user connector PC
J2	28-08044H06	26-pin bus connector
J3	28-08514G02	6-pin test connector
		Transistor (see note 1)
Q1 thru 4	----	Not used
Q5, Q6	48-00869648	M9648, NPN type
Q7, Q8	48-08237G05	VN0106N3 VMOS
		Resistor fixed: ±5% unless otherwise noted
R1 thru 8	----	Not used
R9 thru 14	06-11009C49	1 k
R15	06-00124B46	10 M
R16 thru 24	----	Not used
R25	06-11009D20	820 k
R26	06-10621E46	392 k, 1%
R27	06-11009C79	18 k
R28	06-11009C55	1.8 k
R29	06-10621B10	133, 1%
R30	06-11009C89	47 k
R31	06-11009C97	100 k
R32	06-11009C95	82 k
R33	06-11009C65	4.7 k
R34	06-11009C76	13 k
R35	06-83600K06	10 k, at 25°C
R36	06-10621C28	2.21 k, 1%
R37	06-11009C49	1 k
R38	18-02467C21	Potentiometer 5 k
		Switches
S1, S2	40-83849F02	DIP switch, 8 switches
S3	40-08242G01	Momentary pushbutton
		Integrated Circuit (see note 1)
U1	51-08244G53	74HC165N
U2	51-02599K14	Resistor network 9 X 220k SIP
U3	51-02599K12	Resistor network 7 X 100k SIP
U4	51-02599K14	Resistor network 9 X 220k SIP
U5	51-02187C28	MC146805E2CP
U6	51-08244G34	74HC373N
U7	51-02150C05	Resistor network 8 X 1k
U8	51-02156C37	27C64, (FLN4449A)
U9	51-02156C48	RAM TC5564PL
U10	51-02073C39	MC14541BCL
U11	51-08244G04	74HC00N
U12	51-08244G08	74H04
U13, U14	51-08244G53	74HC165N
U15, U16	51-02599K14	Resistor network 9 X 220k SIP
		Zener Diode
VR5	48-83461E36	6.2 V, IN4735A
VR6	48-02064C82	3.9 V 50 uA 250 mW
		Varistor
VZ1 thru 12	06-02597K06	MOV, 45 V, V56ZA8
		Crystal (see note 1)
Y1	48-82611M09	4.9152 MHz
	14-82590G01	crystal insulator
		Hybrid
Z1 thru Z3	51-08404H01	Input Sensing and Surge Protection
	Non-Referenced Items	
	84-02652L01	Printed Circuit Board
	09-02134C06	IC socket 40-pin, for U5
	09-02134C07	IC socket 28-pin, for U8
JU1	28-02218K12	2-pin for mini-jumper
JU1	29-02219K01	mini-jumper

FLN4347A Housing PL-0380-O

Reference Symbol	Motorola Part No.	Description
	02-02427C01	Lock nut 4x40, 1 used
	03-08026H05	Captive screw 8X32 7/8", 2 used
	03-82210E15	Captive screw, 2 used
	15-08513H01	Housing bottom, 1 used
	15-08586G01	Housing cover, 1 used
	15-08587G01	Door box, 1 used
	22-02482C02	Dowel pin, 1 used

FLN5720A Hardware Kit PL-0381-O

Reference Symbol	Motorola Part No.	Description
	01-02717G06	Terminal & wire, 1 used
	03-00129675	Lock screw 4x40x1/4; 2 used
	03-00134309	Lock screw 4x40x3/16
	31-08509G04	14-pin user conn.
	54-08125H01	Connector label

FLN4625A Label Kit PL-0382-O

Reference Symbol	Motorola Part No.	Description
	54-02243L01	FCC Label
	54-08635G21	Front panel label Add label

FLN4624A EPROM Kit PL-0637-O

Reference Symbol	Motorola Part No.	Description
	12-02897H66	Test procedure
	51-02156C37	EPROM 8kx8

Note 1: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

Note 2: When ordering quartz crystal units or ceramic resonators, specify carrier frequency, crystal (or resonator) frequency and crystal (or resonator) type number.

MOTOROLA INC.
Communications Sector

MAINTENANCE

1. DISASSEMBLY

Refer to the disassembly instructions located in the Installation section of this manual.

1.1 VCC ADJUSTMENT

Attach the positive terminal of a voltmeter to the cathode (+) of VR5 and the negative (-) terminal to the anode of VR5. Adjust potentiometer R38 so that the meter reading is 5 V (±0.1 V).

1.2 JUMPERS

JU1 Watchdog Timer:
Connected - enabled (normal operation)
Disconnected - disabled.

JU2-JU7:
Are fixed and should not be changed for normal operation.

2. CI-6 SELF-TEST AND DIAGNOSTICS

An easy-to-use tool for diagnostics and self-test is available.

The self-diagnostics LED presents the result of the self-test by a number of flashes (see Table 1. LED Indication).

The diagnostics function is activated by a pushbutton or by the test connector (J3 pin 4) connected to ground momentarily. The LED also flashes at power-on. The errors are accumulated as long as the module is connected to the supply voltage. To clear the error buffer, disconnect the module from the supply momentarily.

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Table 1. LED Indication, Detailed Diagnostic

Number of Flashes	Diagnostic	Corrective Action/ Failure Description
No flashes	Power	Check power or LED failure
No flashes LED on	Defective EPROM or microprocessor	Replace EPROM and/or microprocessor
Two flashes	Normal Operation	
Three or nine flashes	CI-6/ES-8 interface failure	Check parameter conflict or replace CI-6 and/or replace bus flat cable
Four flashes	Microprocessor	Replace microprocessor
Five flashes	EPROM failure	Replace EPROM
Six or eight flashes	Software failure	Reset the CI-6 by disconnecting power
Seven flashes	External RAM	Replace external RAM

SPECIAL PRODUCTS

1. GENERAL

Several special features are incorporated into the CI-6 module, which may be ordered as Special Product (SP).

a. Various combinations of functions per group. Up to six different functions per module.

b. Different DELTA parameters per group.

c. Various function parameters. Different range for pulse rate (up to 100 Hz), 0-13.5/15 pulse duration. Different prescallers for the counters.

d. Two-input functions to eliminate bouncing and noise problems, (especially when the input to the function is a relay).

e. Mask capability for status, provided as an input to the module (equal to the FREEZE/RUN, FREEZE & RESET/RUN inputs).

f. Breaker reclosure function intended for tracking and reporting the automatic operation of a breaker control mechanism in an electric system.

g. Different module configuration - 8 status, 4 functions (w/o FREEZE/RUN, FREEZE & RESET/RUN).

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INTRAC 2000
Modular Remote Unit
Counter Input

68P02942G75-O

MOTOROLA INC.
*Communications
Sector*

EXTERNAL RADIO INTERFACE

Model FLN1459A

GENERAL DESCRIPTION

The External Radio Interface module (XRI) is an extender board for the MRU bus, which provides the radio signals. The XRI is included in MRU models without radio and permits the connection of an external radio instead of the standard MRU radio.

The XRI provides control signals (CM and PTT), audio signals (FST and FSR) and ground reference. Verify that the signal of the external radio matches the XRI signal. The module also enables "shared radio" operation with an MRU radio.

NOTE

If an external radio is used as shared radio, make sure that the radio activates a CM busy signal upon a PTT signal.

RADIO CONNECTION

The signal functions are as follows:

CM	(Channel Monitor) indicates if the radio channel is free. The CM line is pulled up by a resistor in the MRU Decoder and Encoder. The polarity of the CM is negative by default (CM is low if busy). Use jumper JU8 in the Encoder and JU2 in the Decoder to change the polarity (the polarity of the CM at the Decoder is DONT CARE if the reception condition by CM parameter is set to NO by default). The voltage limits for CM are: max 5 V dc, min 0 V dc. The logic levels are: min. high logic 3.5 V dc, max low logic 0.8 V dc.
PTT	(Push To Talk) controls radio transmission. The PTT is an open collector, negative logic (low voltage forces a transmission). The max. low voltage is 1.1 V dc/100 mA.
FST	(Frequency Shift Transmission) is the MRU output tone deviation as well as the radio input. The FST is less than 1.1 V rms (100 mV rms by default) adjustable by potentiometer (R45 in the Encoder). For more information see the 68P02933G20 Encoder instruction manual.

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FSR (Frequency Shift Receiving) is the MRU input deviation as well as the radio output. The FSR is less than 1.1 V rms. Refer to 68P02928G55 Decoder instruction manual for more information.

GND (Ground) the signal grounding.

NOTE

To connect an external radio, a five-wire (max 10 feet) shielded cable is recommended.

'Table 1. Connection of the XRI and the Radio

XRI (J1)	External Radio
9 CM	Channel Monitor
10 GND	Ground
11 FSR	Audio output to the radio
13 FST	Audio input to the radio
14 PTT	Push To Talk

EXTERNAL POWER SUPPLY

The XRI is powered through the Data Cable (bus). The power supply to the MRU is connected to the Encoder. In MRU without Encoder, the power supply is connected to the Wireline Interface (WLI). In MRU without Encoder and without WLI, the power supply is connected to the Decoder. The power supply is 24 V ac typical, or 24 V dc typical, or 12 V dc typical. Switching between 12 V dc and 24 V dc/ac is via jumper (JU6 for Encoder, JU100 for Decoder and JU10 for WLI).

DESCRIPTION OF SHARED RADIO OPERATION

The Shared Radio option (V222) enables the expansion of the input/output capacity of the MRU using one radio for several MRU units. All MRU units so connected must be physically located in the same area.

The configuration of the MRUs sharing the same radio is:

- One MRU with radio and option V222
- Other MRUs: without radio (which includes an XRI, refer to XRI above).

MODE OF OPERATION

- Transmission:

  When one of the Encoders (in one of the MRU units) is ready to transmit a message, it checks the CM signal and waits for a free channel. When the channel is free, it sends a PTT signal to the radio together with the FSK signal on the FST line.

The radio sends the CM busy signal to all MRU units as soon as it perceives that a PTT signal has been received, thus notifying all units that the transmitter line is busy.

- Reception:

When the radio receives an FSK signal it sends a CM busy signal to all MRU units, (thus notifying all units that the receive line is busy) together with the received FSK signal on the FSR line.

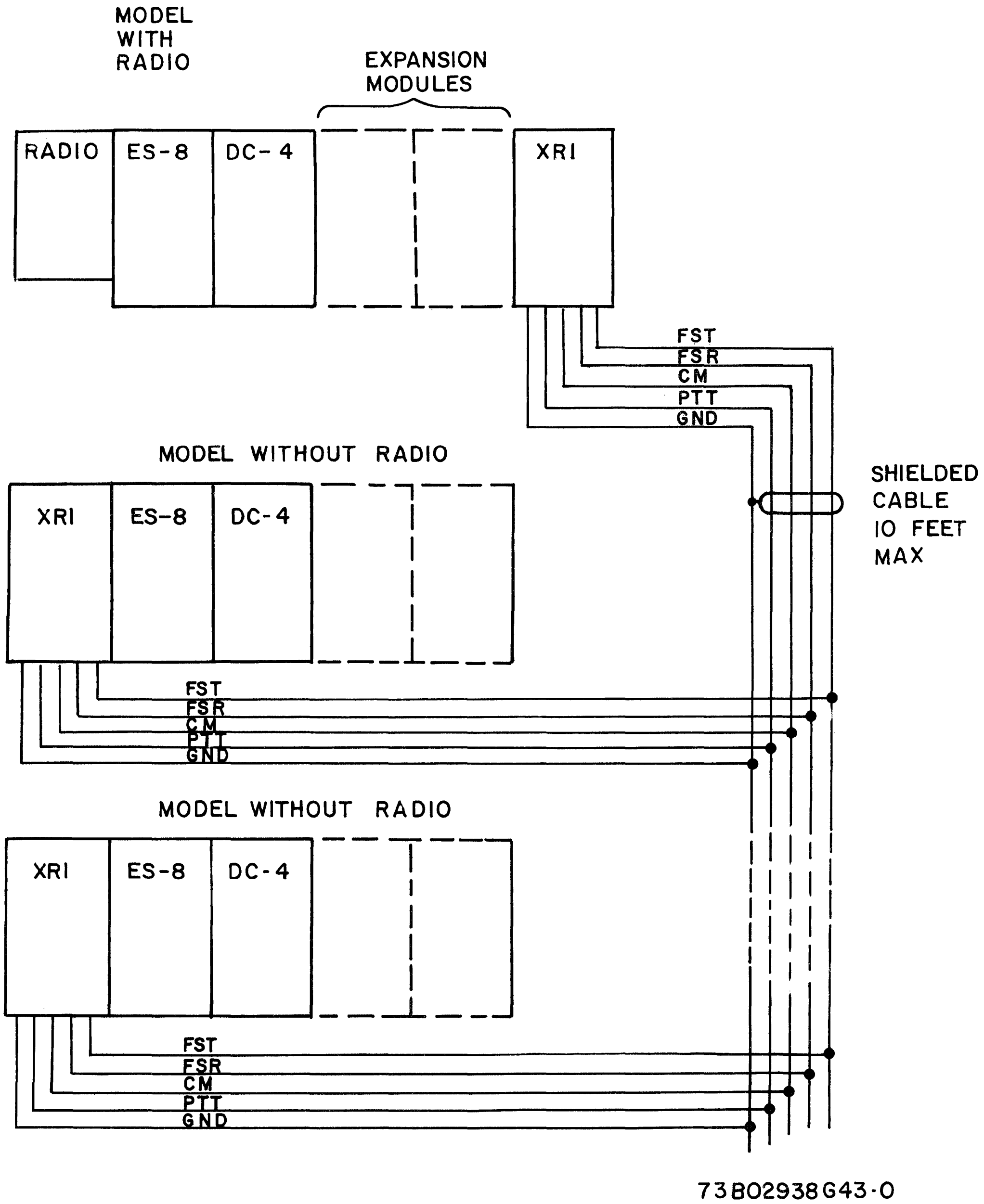


Figure 1. Shared Radio System

parts lists

FLN4384A Printed Circuit Board PL-0428-O

Reference Symbol	Motorola Part No.	Description
	21-05455G01	100 pF; 10 used
	28-08044H06	26-pin connector
	28-08508G04	14-pin connector
	84-02333L01	PC Board

FLN4405A Label Kit PL-0249-O

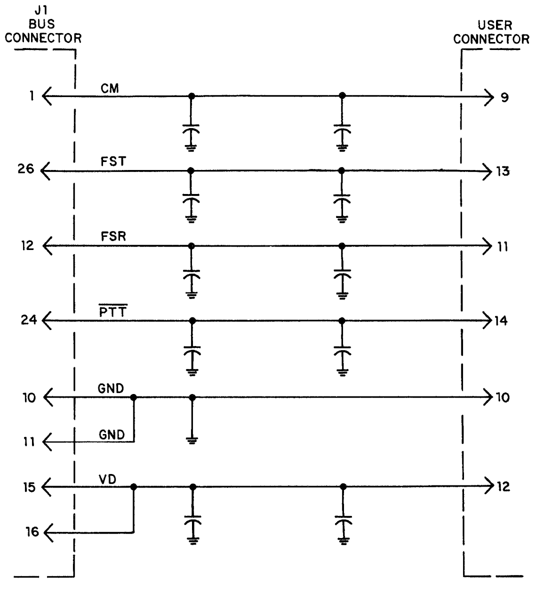
Reference Symbol	Motorola Part No.	Description
	54-02443L01	FCC Label
	54-08124H10	Address Label
	54-08635G15	Front Panel Label
	71-02940G72	Production Process

FLN4347A Housing PL-0380-O

Reference Symbol	Motorola Part No.	Description
	02-02427C01	Lock nut 4X40, 1 used
	03-08026H05	Cap scr 8X32 7/8", 2 used
	03-82210E15	Captive screw, 2 used
	15-08513H01	Housing bottom, 1 used
	15-08586G01	Housing cover, 1 used
	15-08587G01	Door box, 1 used
	22-02482C02	Dowel pin, 1 used

FLN5720A Hardware Kit PL-0381-O

Reference Symbol	Motorola Part No.	Description
	01-02717G06	Terminal & wire, 1 used
	03-00129675	Lock scr 4x40x1/4 2 used
	03-00134309	Lock scr 4x40x3/16 1 used
	31-08509G04	14-pin user conn 1 used
	54-08125H01	Connector label, 1 used



NOTE: ALL CAPACITORS ARE 100pF
MOTOROLA NO. 21-05455G01.

73B02967G46-O

Figure 2. External Radio Interface

MOTOROLA INC.

instruction manual revision

GENERAL

This revision details changes that should be made in your instruction manual. Please correct your manual accordingly.

INSTRUCTION MANUAL AFFECTED

68P02943G15-O Modular Remote Unit, Voice and Radio Interface

REVISION DETAILS

1. In the 68P02953G68 General Description section, page 3 paragraph 2.3 External Radio Interface, should read:

2.3 EXTERNAL RADIO INTERFACE

The CM signal from the external radio is connected to CM on the user connector, and fed directly to the CM of the bus connector. The CM signal, from an external or internal radio can be inverted (if it is active high) before being used by the VRI module. If the external radio does not provide a CM signal, but has a squelch circuit, the FSR signal is also connected (via a variable control) to the VRI module's internal channel monitor, this provides the CM signal to the bus and user connectors.

2. In the 68P02953G69 Installation section:

2.1 Paragraph 3.2 Transmit Voice Channel should be changed as follows;

The preset transmit levels are obtained by setting JU6 to position A. The factory default setting is with R2 and R4 connected, when the VRI module is used in a system including an Encoder module. If no Encoder module is included and a radio with an input impedance of 3 to 4k ohm is used, (as the F6456A DARCOM 960 MHz, and all the F62XXA HT440 radio models) the R2 is disconnected (the resistor may be unsoldered or cut).

2.2 Paragraph 3.7 Special Installations, add after first d:
e. If CM is provided on receive, set JU4, JU5 to suit signal polarity.

Replace second a. with:
a. Set JU6 to position A and R2, R4 to suit radio/WLI combination as shown in table VRI Jumper Table.

2.3 Exchange attached white page 3a with page 3 in the Installation section.

3. In the 68P02953G71 Theory of Operation section:

3.1 In paragraph 3, External Radio Interface, the sentence beginning with "The CM signal ...." should read:

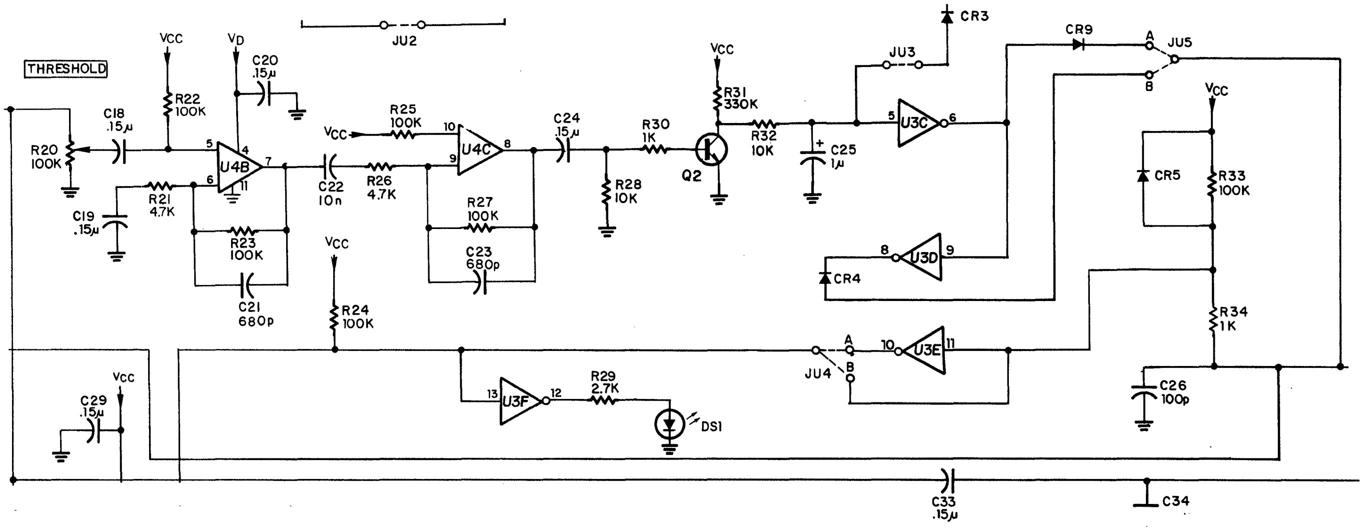
The CM signal from the external or internal radio (user connector pin 5, bus connector pin 1) is fed via R34 to inverter U3E and JU4. If the external CM signal goes above +5 V, R34 together with CR5 clamp the CM voltage to Vcc.

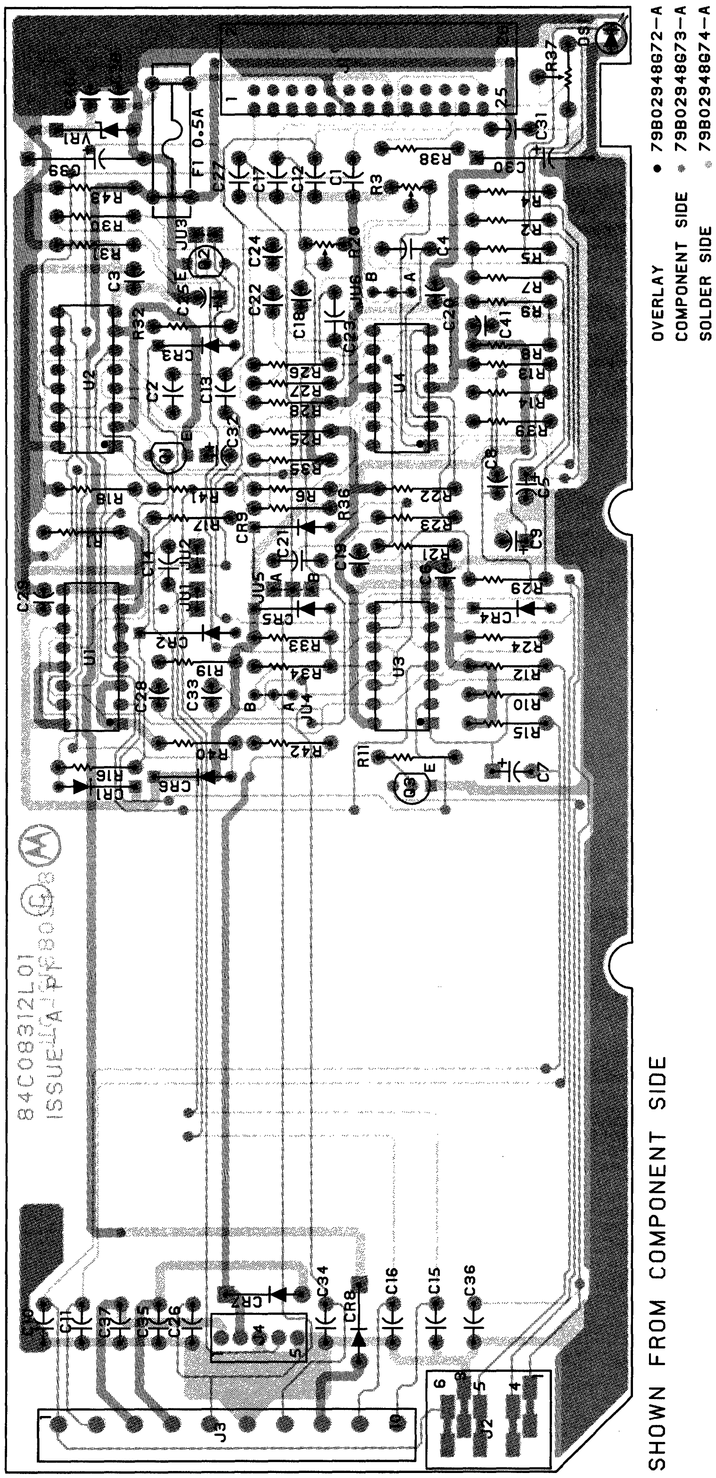
3.2 The sentence beginning "If the external...." should read:

If the radio provides an active high CM signal, then JU4 is set to position A and the signal is inverted to the normal active low state; otherwise, JU4 is set to position B. JU5 is always set to the same position (A or B) as JU4. When CM is low, U3F output is high causing the green LED DS1 to light.

3.3 The yellow page 3 of 4 is an updated version of the FLN4636A VRI Main Board Printed Circuit Board Detail found on page 4.

3.4 The following is the change which should be added to page 5 FLN4636A VRI Main Board schematic diagram:




OVERLAY ● 79B02948G72-A
COMPONENT SIDE ● 79B02948G73-A
SOLDER SIDE ● 79B02948G74-A
SHOWN FROM COMPONENT SIDE
84C08312L01
ISSUE A
F1 0.5A
VR1
U1
U2
U3
U4
J2
J3

FLN4636A VRI Main Board
Printed Circuit Board Detail
March, 1988

3.5 In the FLN4636A VRI Main Board parts list see the following changes:

FLN4636A VRI Main Board PL-0647-O

Reference Symbol	Motorola Part No.	Description
		Diode
CR1	48-11034A01	1N4148
CR2	48-84616A01	HPA5082-2877
CR3 thru CR6	48-11034A01	1N4148
CR7, CR8	48-82466H13	silicon
add the following:		
CR9	48-11034A01	1N4148
		Jumper
JU1	28-02218K12	jumper header 2-pin
JU2	-----	not used
JU3	28-02218K12	jumper header 2-pin
JU4	28-82622L01	jumper header 3-pin
change JU5 for:		
JU5, JU6	28-82622L01	jumper header 3-pin
		Integrated Circuit
U1, U2	51-08244G64	triple analog switch
U3	51-83808P10	hex schmitt trigger inv
change U4 for:		
U4	51-02162C18	quad op amp
		Resistor
R16	06-11009D06	220k
R17	06-11009C97	100k
R18	06-11009C99	120k
R19	----	not used

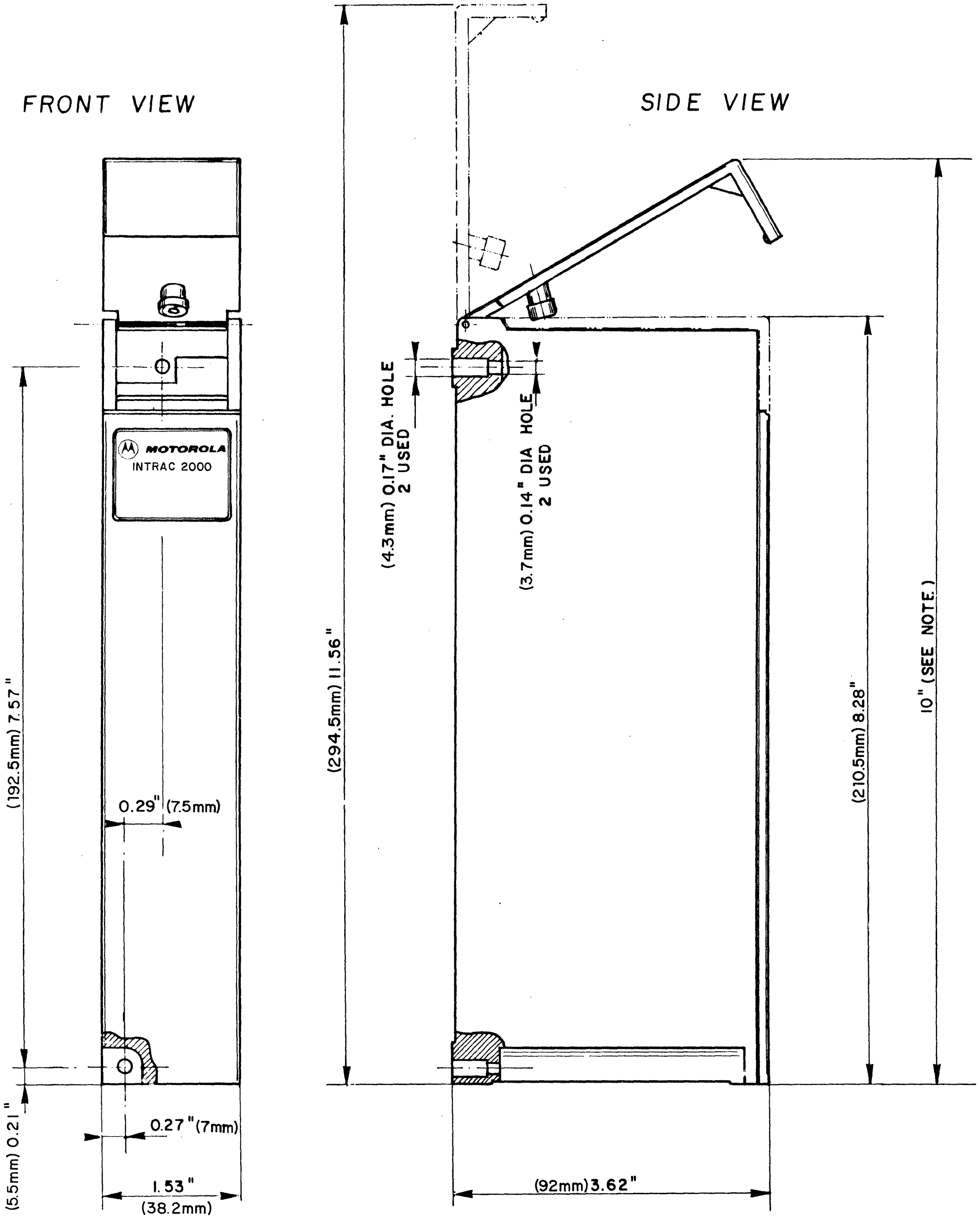
VRI JUMPER TABLE

JUMPER	CONNECTION	FUNCTION
JU1		When connected, short's out CR2 for VRI module; used in shared radio mode with internal radio
JU2	Not connected	Factory use only
JU3	Not connected Connected	Radio connects PTT to CM Connects PTT to CM if radio does not include this capability
JU4, JU5	Set to A Set to B	If radio CM signal is active high If radio CM signal is active low
JU6	Set to A Set to B	R2, R4 (fixed transmit levels) are used R3 (variable transmit level) is used

VRI RECOMMENDED JUMPER SETTINGS FOR DIFFERENT SYSTEMS

RADIO	RADIO/VRI INTERFACE	R2	R4	JU1	JU3	JU4	JU5	JU6
Default/less radio	Bus/User	v	v	-	-	B	B	A
DARCOM/WLI with DARCOM	Bus	v	v*	v	v	A	A	A
HT440/WLI with HT440	Bus	v	v*	v	-	B	B	A
MAXAR	User	v	v	-	-	A	A	A
WLI with MAXAR	Bus	v	v*	v	-	A	A	A
MC-MICRO	User	v	v	-	v	B	B	A
WLI with MC-MICRO	Bus	v	v*	v	v	B	B	A
WLI without Radio	Bus	v	v*	v	v	B	B	A

* Disconnect R4 if system does not include an Encoder module.



NOTE

MINIMUM OPENING FOR REMOVING WIRE CONNECTOR.

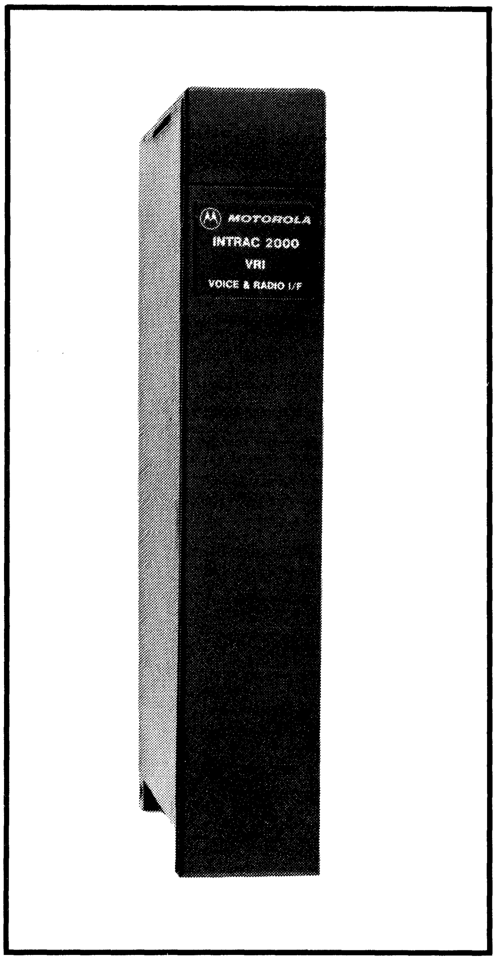
73C02936G40-0

Figure 1. Housing Detail

MOTOROLA

INTRAC 2000®

Modular Remote Unit
Voice and Radio Interface



Instruction Manual

68P02943G15-0

COMMERCIAL WARRANTY
(STANDARD)

Motorola radio communications products are warranted to be free from defects in material and workmanship for a period of ONE (1) YEAR, (except for crystals and channel elements which are warranted for a period of ten (10) years) from the date of shipment. Parts, including crystals and channel elements, will be replaced free of charge for the full warranty period but the labor to replace defective parts will only be provided for One Hundred-Twenty (120) days from the date of shipment. Thereafter purchaser must pay for the labor involved in repairing the product or replacing the parts at the prevailing rates together with any transportation charges to or from the place where warranty service is provided. This express warranty is extended by Motorola Communications and Electronics, Inc., 1301 E. Algonquin Road, Schaumburg, Illinois 60196, to the original purchaser only, and only to those purchasing for purpose of leasing or solely for commercial, industrial, or governmental use.

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In the event of a defect, malfunction or failure to conform to specifications established by seller, or if appropriate, to specifications accepted by Seller in writing, during the period shown, Motorola, at its option, will either repair or replace the product or refund the purchase price thereof, and such action on the part of Motorola shall be the full extent of Motorola's liability hereunder.

This warranty is void if:

a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage;
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

This warranty extends only to individual products, batteries are excluded, but carry their own separate limited warranty. Because each radio system is unique, Motorola disclaims liability for range, coverage, or operation of the system as a whole under this warranty except by a separate written agreement signed by an officer of Motorola.

Non-Motorola manufactured products are excluded from this warranty, but subject to the warranty provided by their manufacturers, a copy of which will be supplied to you on specific written request.

In order to obtain performance of this warranty, purchaser must contact its Motorola salesperson or Motorola at the address first above shown, attention Quality Assurance Department.

This warranty applies only within the United States.

EPS-27734-O

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EPS-34440-B

MOTOROLA INC.
Communications
Sector

INTRAC 2000®
Modular Remote Unit
Voice and Radio Interface

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3. External Radio Interface 2
4. Shared Radio 3

AUDIO AMPLIFIER 68P02954G82-O

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technical writing services
1301 E. Algonquin Road, Schaumburg, Il. 60196

FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar equipment. The information it contains is current as of the printing date. Subsequent engineering changes are described in supplementary Instruction Manual Revisions (IMRs) issued as needed. The applicable schematic diagram is updated and the changes are described in a revision column printed either on the diagram or next to the corresponding parts list.

2. SERVICE

The Motorola National Service Organization offers one of the finest nationwide installation and maintenance programs available to communications equipment users. This organization comprises approximately 900 Motorola Service Stations located throughout the United States. Each Service Station is independently owned and operated, is staffed by one or more trained, FCC-licensed technicians, and is specially selected and authorized by Motorola.

The administrative staff of the National Service Organization consists of national, area and district service managers, and district representatives, all of whom are Motorola employees. Their objective is continually to improve the service to Motorola customers.

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National Service Manager
Motorola Communications and Electronics
Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

3. MODEL AND KIT IDENTIFICATION

Every Motorola product is specifically identified by an overall model number printed on the nameplate. In addition, the assemblies and kits comprising the product usually have kit model numbers stamped on them.

4. REPLACEMENT PARTS ORDERING

Motorola maintains a **factory parts center** and several **area parts centers** located throughout the United States. These facilities are equipped to process parts orders, identify part numbers, and otherwise assist in the maintenance and repair of Motorola Communications Group products. The addresses of these parts centers are listed on the following page.

Orders for crystals, channel elements, active filters, PROMs, code plugs, and resonant reeds should be

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sent directly to the **factory parts center.** Orders for all other parts and for instruction manuals should be sent to the nearest **area parts center.**

All orders for replacement parts or equipment information should include the complete identification number. This requirement applies to all components, kits and chassis. If the component part number is not known, the order should include the number of the chassis or kit which uses it, and a description of the desired component sufficient to identify it.

Orders for crystals and channel elements should specify the crystal or channel element type number, crystal and carrier frequencies, and the model number of the chassis using the part.

Orders for active filters, PROMs, code plugs, and "Vibrasender" and "Vibrasponder" resonant reeds, should specify type number and frequency, and should identify the owner/operator of the communications system utilizing these items.

5. ADDRESSES

5.1 AREA PARTS CENTERS

5.1.1 U.S. Orders

Western Area Parts
1170 Chess Drive, Foster City
San Mateo, California 94404
Telephone: 415-349-3111
TWX: 910-375-3877

Midwest Area Parts
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-7322
TWX: 910-693-0869

Mid-Atlantic Area Parts
7230 Parkway Drive
Hanover, Maryland 20176
Telephone: 301-796-8600
TWX: 710-862-1941

East Central Area Parts
12995 Snow Road
Parma, Ohio 44130
Telephone: 216-267-2210
TWX: 810-421-8845

Eastern Area Parts
85 Harristown Road
Glen Rock, New Jersey 07452
Telephones: 201-447-4000
TWX: 710-988-5602

Pacific Southwestern Area Parts
P.O. Box 85036
San Diego, California 92138
Telephone: 714-578-2222
TWX: 910-335-1634

Gulf States Area Parts
8550 Katy Freeway, Suite 128
Houston, Texas 77024
Telephone: 713-932-8955

Southwestern Area Parts
P.O. Box 34290
3320 Belt Line Road
Dallas, Texas 75234
Telephone: 214-241-2151
TWX: 910-860-5505

Southeastern Area Parts
P.O. Box 368
Decatur, Georgia 30031
Telephone: 504-981-9800
TWX: 810-766-0876

5.1.2 Canadian Orders

Motorola Ltd.
National Parts Department
3125 Steeles Avenue
E. Willowdale, Ontario M2H 2H6
Telephone: 416-499-1441
TWX: 610-492-2713
Telex: 065-25191

5.1.3 All Other Countries

Motorola Inc., or
Motorola Americas, Inc.
International Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
U.S.A.
Telephone: 312-576-6492
TWX: 910-693-0869
Telex: 722443 or 722424
Cable: MOTOL PARTS

5.2 FACTORY PARTS CENTER

5.2.1 Mail Orders

Motorola, Inc.
Component Products Sales and Service
P.O. Box 66191
O'Hare International Airport
Chicago, Illinois 60666

5.2.2 Other Correspondence

Motorola, Inc.
Component Products Sales and Service
2553 N. Edgington Street
Franklin Park, Illinois 60131

5.3 GENERAL OFFICES

Motorola Communications and Electronics Inc.
Communications Group Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-3900

PERFORMANCE SPECIFICATIONS

GENERAL

Power Input; Main Module	11-15 V dc current consumption: 30 mA maximum
Optional Audio Amplifier	Separate 11-15 V dc supply for the optional audio amplifier, nominal current consumption 250 mA at normal listening level (1.5 W)
Operating Temperature	-30°C to +60°C
Relative Humidity	0-90% without condensation
Housing	Thermo-plastic module
Dimensions	1.6" X 8.3" X 3.7" (H X W X D) 40.64 X 210.82 X 93.98 mm Height with open door 11.6"
Weight	128 oz (360 gr)

RADIO INTERFACE:

Voice from Radio	50 mV to 250 mV rms, 30k ohm input impedance
Voice to Radio	Variable 0 to 1 V rms, or preset levels
Frequency range	300 to 3400 Hz
Channel Monitor Actuation	a. tone detector, 600 to 3400 Hz bandwidth, 10 mV rms to 1.1 V rms (at 1 kHz) adjustable with threshold potentiometer for voice and/or FSK tones. b. PTT low. c. CM from radio, voltage input; low 0.8 V, high 4 V. d. external CM, voltage input; low 0.8 V, high 4 V, active high or low, jumper selectable.

LED Indicator	green LED, located under latch door
PTT actuation	a. PTT switch on handset b. external input active low
PTT output	open collector, active low (100k ohm pull-up to +5 V) V max 25 V I max 50 mA
AUDIO AMPLIFIER	
Output Power	3 W maximum into a 4 ohm loudspeaker at 12 V power supply.

KIT BREAKDOWN

FRN1662A Voice and Radio Interface (VRI)

- FLN4636A Main Board
- FLN4637A Hardware Kit
- FLN4638A Label Kit
- FLN4347A Housing

FRN1744A Audio Amplifier

- TRN6824A 3 W Audio Amplifier
- FLN4826A Conversion Kit

MOTOROLA INC.
Communications Sector

SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.
2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.
3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.
5. Use only a grounded soldering iron.
6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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1301 E. Algonquin Road, Schaumburg, Il. 60196

7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

WARNING

If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.

MOTOROLA INC.
Communications Sector

GENERAL DESCRIPTION

1. GENERAL DESCRIPTION (Refer to Configuration Diagram)

The Voice and Radio Interface module (VRI) is an option (V277) of the MRU family.

The VRI provides three major functions:

- Voice interface allowing voice communication between the remote unit and central station over the radio channel
- External radio interface which configures the voice and radio interface and replaces the External Radio Interface (XRI)
- Shared Radio Interface.

1.1 VOICE COMMUNICATION INTERFACE

1.1.1 Standard Features

The module uses a TMN6057 handset, available as an accessory. The PTT switch on the handset enables voice communication and is automatically disabled after 30 seconds.

The module has preset transmit output levels for standard Motorola radios, and a variable control for non-standard radios.

The received input level is adjustable via a potentiometer (accessible under the latch door) which can be set by the user to a comfortable listening level.

A further option (V140) adds a 3 W audio amplifier to the module for powering an external loudspeaker. The audio amplifier needs a separate connection to the power supply through the user input connector. When connected, it automatically disables the handset earpiece.

Lifting the handset enables automatic switch-over from the audio amplifier to the handset. This feature is available only when using the optional hangup box.

1.1.2 Special Features

A channel disable input allows the voice channel to be enabled/disabled by a control message (communication grant) from the central station (selective calling).

The PTT signal from the handset acts as a communication request (using one status input) to the central. A control output can also be fed into the same point to enable the microphone, so that it monitors any sounds or conversations in the vicinity of the MRU (use momentary relay with preselected duration).

1.2 EXTERNAL RADIO INTERFACE

Both the transmit signal (FST) and the PTT signal coming from the Encoder or from the Voice channel are fed to the radio. The receive signal (FSR) and

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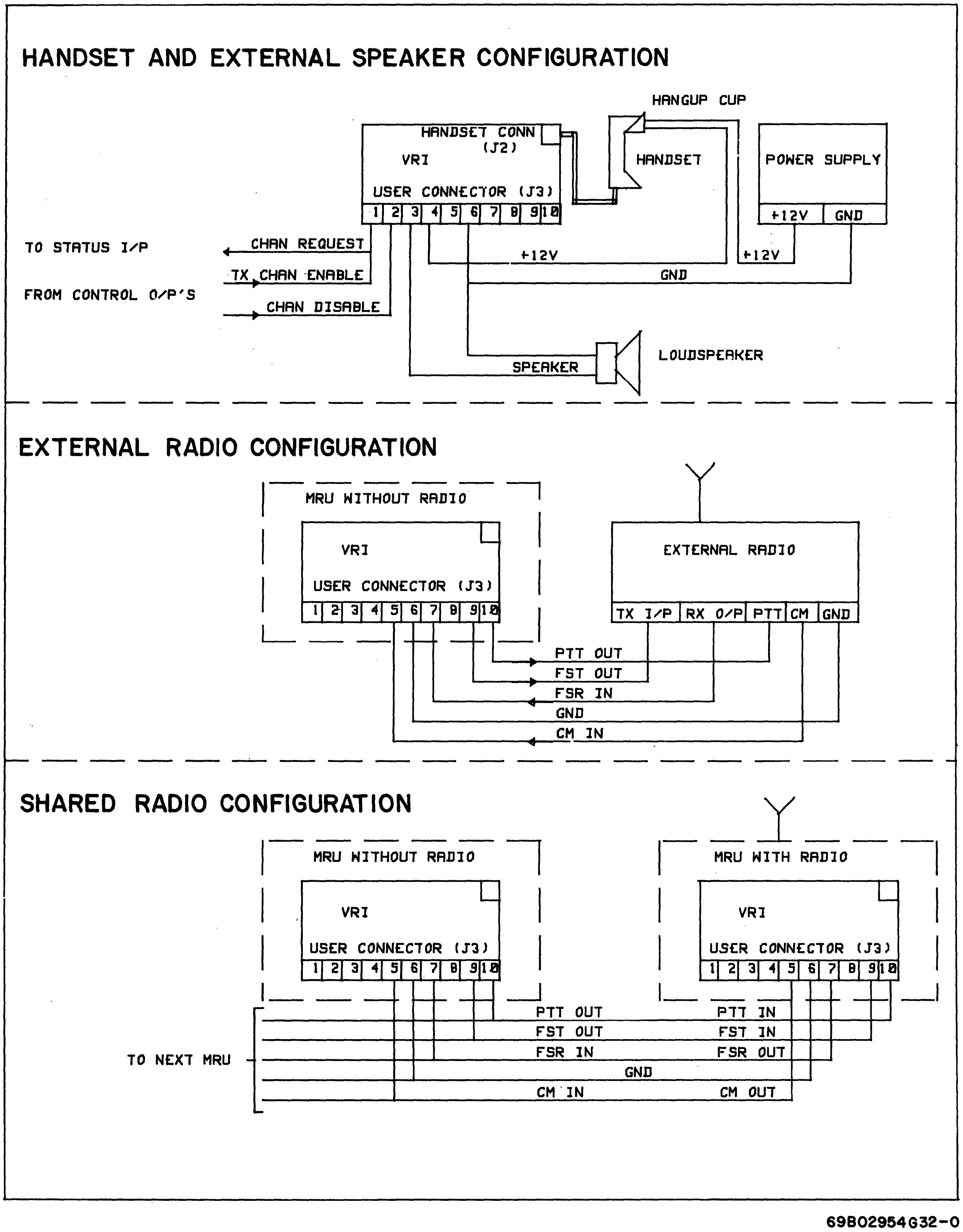

Configuration Diagram

the channel monitor signal (CM) from the radio are fed to the Decoder and to the Voice channel. A tone detector provides the CM signal if the external radio (containing a squelch circuit) does not include this feature.

1.3 SHARED RADIO INTERFACE

This enables several MRU units to be connected to one common radio. Configuring the interface into each MRU unit eliminates the need to readjust the transmit level in each Encoder module.

A Shared Radio system can also be configured with one VRI module connected to the radio and the rest of the MRUs connected to the VRI via XRI units on each MRU, but then the transmit level does have to be adjusted in each Encoder.

2. FUNCTIONAL DESCRIPTION

2.1 TRANSMIT VOICE CHANNEL

The microphone signal from the handset is amplified and connected to the bus FST via an analog switch which is enabled by a PTT signal from the handset. The amplitude of the signal is preset to suit the radio signal input for standard Motorola radios, but can also be adjusted for non-standard radios by a variable control. The PTT from the handset is also transferred to the PTT signal of the bus connector.

2.2 RECEIVE VOICE CHANNEL

The FSR signal on the bus connector (coming from the radio receiver) is fed via an analog switch to an amplifier. This analog switch is enabled by the CM signal. The audio signal after amplification is fed either to the handset or to the optional (FRN1744A) audio amplifier. The signal path selection is carried out automatically based on the presence or absence of audio amplifier supply voltage.

2.3 EXTERNAL RADIO INTERFACE

The FST signal on the bus connector (which can be from the Encoder or from the transmit voice channel) is connected to the user connector FST (via an analog switch) for transfer to the external radio. This analog switch is enabled by the PTT signal on the bus connector. The PTT on the bus connector is also fed out to PTT on the user connector for the external radio.

The FSR signal from the external radio receiver is connected to the user connector and then fed directly to FSR on the bus connector.

The CM signal from the external radio is connected to CM on the user connector. The CM signal can be inverted, (if its polarity is incorrect) and is then fed to the CM of the bus connector. If the external radio does not provide a CM signal, but does have a squelch circuit, the FSR signal is also connected, via a variable control, to the VRI module's internal channel monitor, this provides the bus CM signal.

2.4 SHARED RADIO

The FST, FSR, CM and PTT signals from other MRUs are connected to the user connector, and then transferred to the bus connector and thus to the shared radio.

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INSTALLATION

1. PRELIMINARY

Carefully inspect the VRI module immediately upon receipt and notify the shipper of any damage that has ocurred in transit. The installation procedure consists of making the necessary external and internal electrical connections (see Figure 1. Housing Detail).

2. DISASSEMBLY

To access jumpers the VRI must be disassembled. Follow the directions below for proper disassembly of the VRI housing (refer to Figure 2. Disassembly).

Step 1. Loosen the two screws on the right panel of the VRI housing.

Step 2. Lift the latch door located at the top of the housing.

Step 3. Gently separate the two sides, the PC board is now exposed.

3. ADJUSTMENTS

3.1 GENERAL

(Refer to Figure 3. PC Board Detail)

Changing jumper settings involves delicate work on the PC board. This operation is best performed first before any connections are made to the VRI module.

CAUTION

1. Touch the metal coating inside the housing before changing any jumper setting, to dissipate any static charge that might otherwise damage the CMOS integrated circuits.

2. Do not attempt to change jumper settings intended for factory use only.

3.2 TRANSMIT VOICE CHANNEL

The preset transmit levels are obtained by setting JU6 to position A and disconnecting either R2 or R4 (the resistor may be unsoldered or cut). If R2 is disconnected, then the transmit level is suitable for MAXAR radios (160 mV into 600 ohm). If R4 is disconnected, then the transmit level is suitable for F6456A (DARCOM) 960 MHz band and all F62XXA (HT440) radio models (100 to 130 mV into 3 to 4k ohm).

The variable transmit level is obtained by setting JU6 to position B and adjusting potentiometer R3 to suit the specific radio in use. The maximum output available from R3 is about 1 V rms during normal speech.

3.3 RECEIVE VOICE CHANNEL

The receive volume level can be adjusted at any time by opening the latch door of the module and varying potentiometer R37 (VOLUME).

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Channel monitor threshold control (R20) is normally left at minimum (counter-clockwise) so that the VRI's internal channel monitor is disabled (see paragraph 3.4).

3.4 EXTERNAL RADIO INTERFACE

Set jumpers JU3 to JU6 to suit the external radio.

If the external radio does not provide a CM signal but has squelch, the squelch control on the radio should be adjusted so that the radio is quieted when not receiving a voice or FSK signal.

The radio receiver output on voice or FSK should be adjusted to be within the range of 50 to 250 mV rms.

While the radio is receiving a voice or FSK signal, slowly increase the channel monitor threshold control (R20) (turn clockwise) until the green CM LED (DS1) lights up, then add another 1/2 turn. Check with both voice and FSK signals (and readjust if necessary) that the CM LED lights when the radio is receiving a signal and goes out when the radio has squelched.

3.5 SHARED RADIO

Jumper settings are the same as external radio interface, except for JU1 connected on the VRI module with an internal radio.

3.6 AUDIO AMPLIFIER

The audio amplifier output level is factory preset to give approximately 1.5 W with the volume control on the VRI module set to give a normal listening level on the handset.

To change this setting, adjust the volume control (R37) to give the desired listening level on the handset; connect the external power supply to the audio amplifier so as to switch the audio output to the loudspeaker and then adjust the preset control on the audio amplifier module (R4, level set control) to give the required output level.

3.7 SPECIAL INSTALLATIONS

The VRI can be used in many different applications which cannot all be covered in this manual, but the general principles are always the same.

a. Determine transmit level to suit installation and set jumper JU6 and potentiometer R3 accordingly.

b. Determine if PTT is connected to CM by the MRU, if not change JU3.

c. Determine that receive level is within acceptable input range of VRI.

d. If CM is not provided on receive, use internal channel monitor.

As an example, take the following application; an MRU using the Wireline Interface (WLI):

a. The required transmit level is 100 mV into 10k ohm, so set JU6 to position B and adjust R3 for 100 mV on normal speech.

b. WLI does not connect PTT to CM, so connect JU3.

c. Receive level is approximately 130 mV, so it is acceptable.

d. CM is provided on receive, do not use internal channel monitor.

VRI JUMPER TABLE

JUMPER	CONNECTION	FUNCTION
JU1	Not connected* Connected	When connected, short's out CR2 for VRI module; used in shared radio mode with internal radio
JU2	Not connected* Connected	Factory use only
JU3	Not connected* Connected	Connects PTT to CM if external radio does not include this capability
JU4	Set to A Set to B*	Set to position A if the external radio CM signal is active high
JU5	Not connected Connected*	Disconnected if the external radio CM signal can go above Vcc (+5V)
JU6	Set to A* Set to B	Set to position B when R3 (variable transmit level) is used

* Factory default

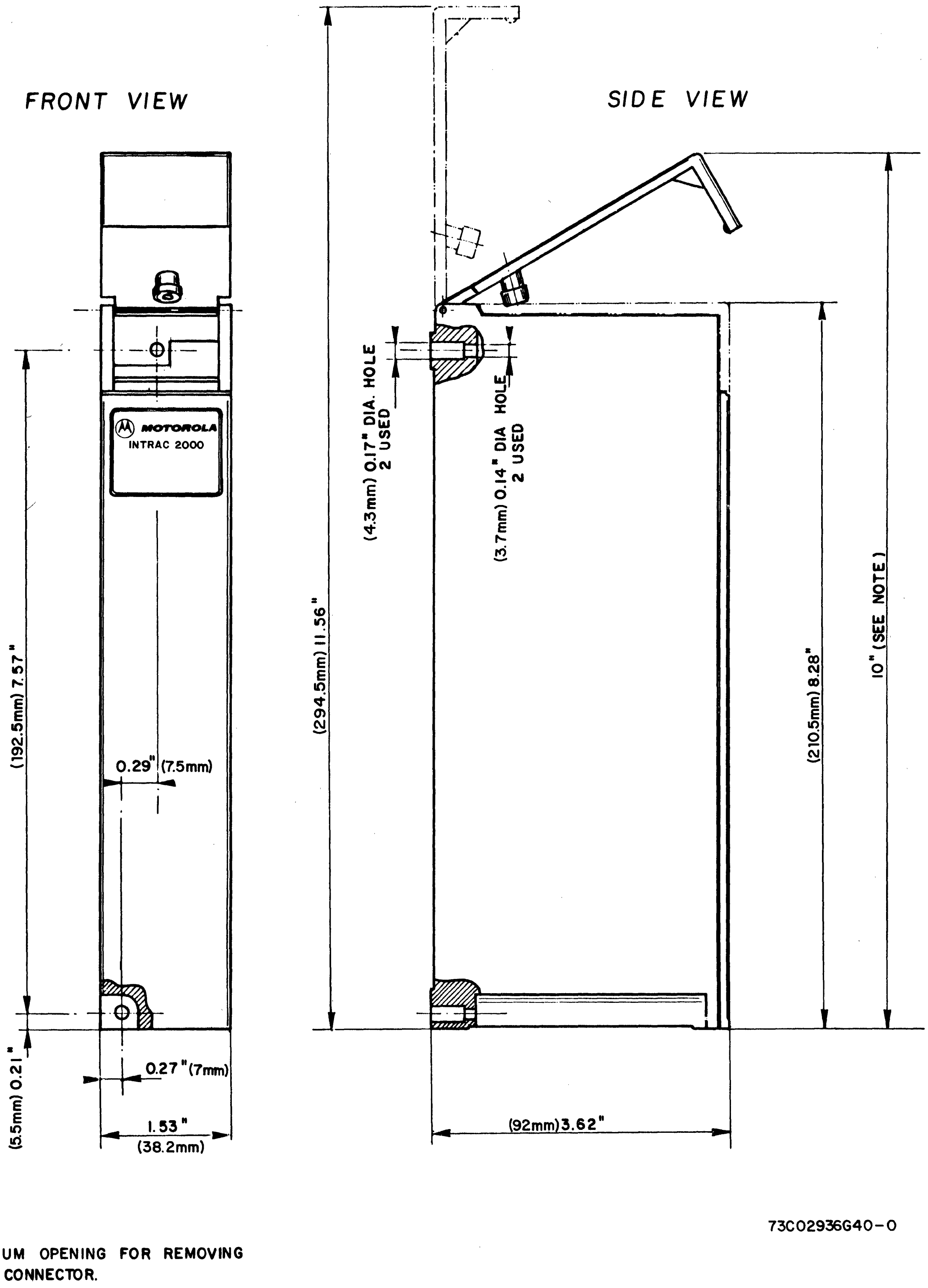


Figure 1. Housing Detail

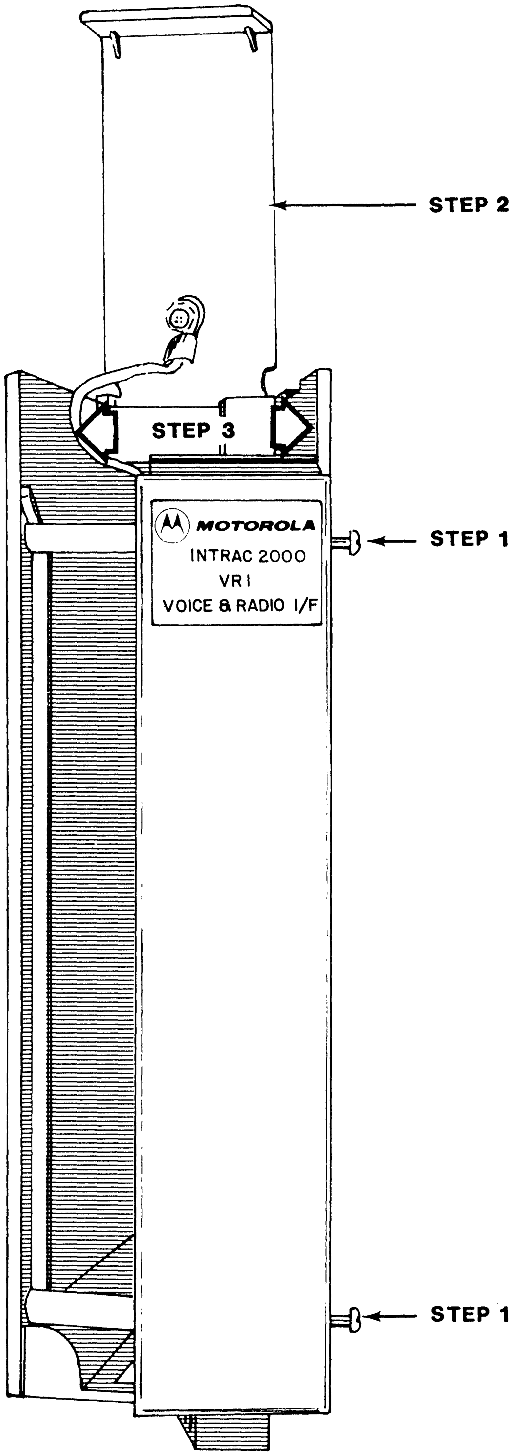


Figure 2. Disassembly

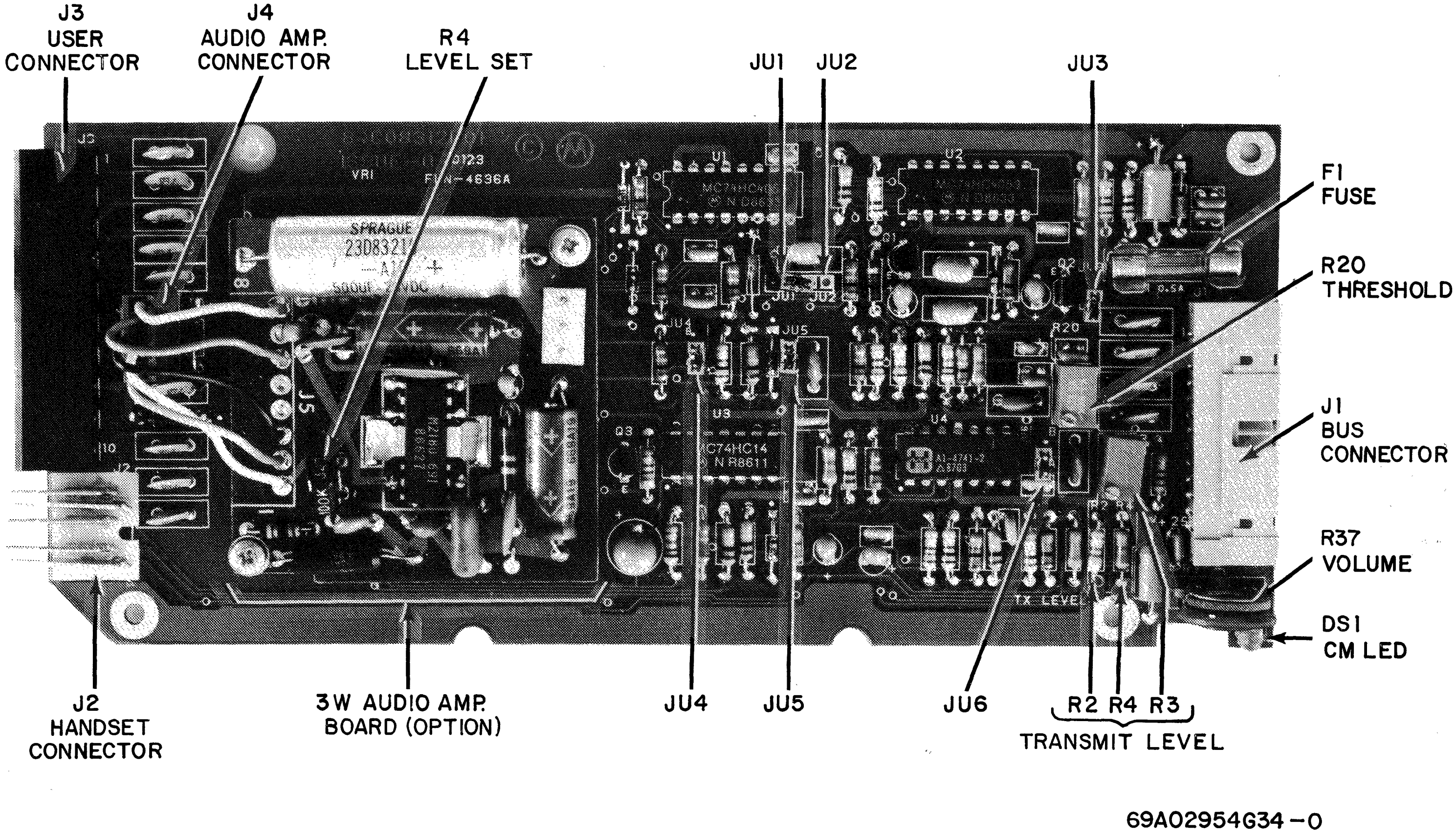


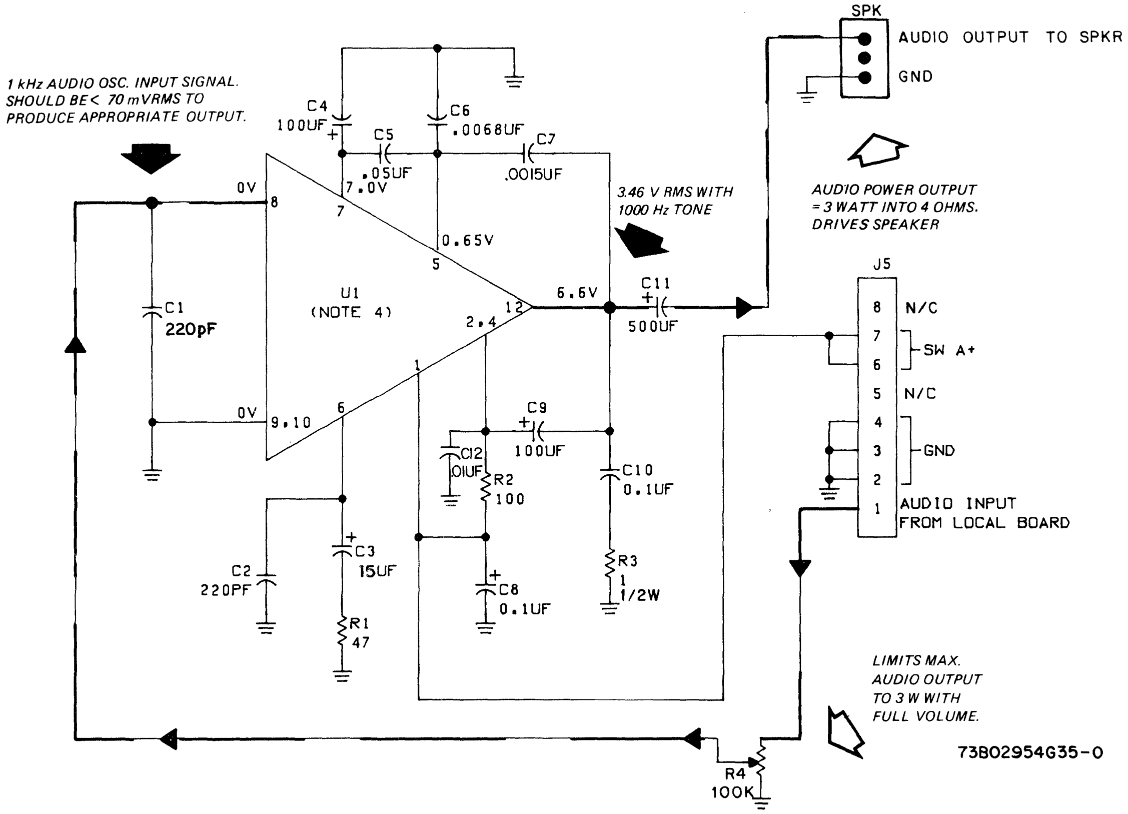
Figure 3. VRI PC Board

parts lists

TRN6824A 3 Watt Audio Amplifier PL-5766-B

Reference Symbol	Motorola Part No.	Description
		Capacitor
C1, C2	21-83596E10	220 pF ±20%; 500 V
C3	23-84762H09	15 uF +100-0%; 20 V
C4	23-84669A19	100 uF +150-10%; 20 V
C5	21-82372C04	.05 uF +80-20%; 25 V
C6	08-84496D08	.0068 uF ±10%; 400 V
C7	21-82187B18	.0015 uF ±10%; 100 V
C8	23-80217J01	0.10 uF ±20%; 35 V
C9	23-84669A19	100 uF +150-10%; 20 V
C10	23-80217J01	0.10 uF ±20%; 35 V
C11	23-83210A19	500 uF +100-10%; 20 V
C12	21-83596E21	.01 uF +80-20%; 200 V
		Connector
J5	09-83795F01	female; 8 contact
	28-83496F28	3-pin
	46-84549F01	polarizing plug
		Resistor
R1	06-00124A17	47 ±5% 1/4 W
R2	06-11009C25	100 ±5% 1/4 W
R3	06-00125B70	1 ±5% 1/2 W
R4	18-84944C11	100k ±20%; 1/10 W
		Integrated Circuit
U1	51-84621K80	3 W audio amplifier
	84-84084L01	printed circuit board

NOTE: For the FRN1744A Audio Amplifier option, conversion kit FLN4826A replaces connector J5 with a cable assembly.



1 kHz AUDIO OSC. INPUT SIGNAL. SHOULD BE< 70 mVRMS TO PRODUCE APPROPRIATE OUTPUT.
C4
100UF
C5
.05UF
C6
.0068UF
C7
.0015UF
0V
8
7
7.0V
0.65V
5
U1
(NOTE 4)
12
2,4
1
6.6V
0V
9,10
6
C1
220pF
C2
220PF
C3
15UF
R1
47
C12
.01UF
R2
100
C9
100UF
C8
0.1UF
C10
0.1UF
R3
1
1/2W
C11
500UF
3.46 V RMS WITH 1000 Hz TONE
SPK
AUDIO OUTPUT TO SPKR
GND
AUDIO POWER OUTPUT = 3 WATT INTO 4 OHMS. DRIVES SPEAKER
J5
8 N/C
7
6
SW A+
5 N/C
4
3
2
GND
1 AUDIO INPUT FROM LOCAL BOARD
LIMITS MAX. AUDIO OUTPUT TO 3 W WITH FULL VOLUME.
R4
100K
73B02954G35-0

NOTES:

1. REFER TO PARTS LIST FOR COMPONENT LISTINGS.
2. UNLESS OTHERWISE NOTED, RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN PICOFARADS.
3. UNLESS OTHERWISE NOTED, DC VOLTAGES ARE MEASURED WITH A 20,000 OHM/VOLT VOLTMETER.
4. U1 VOLTAGES MEASURED WITH VOLUME CONTROL FULLY CLOCKWISE (MAXIMUM VOLTAGE)

LEGEND

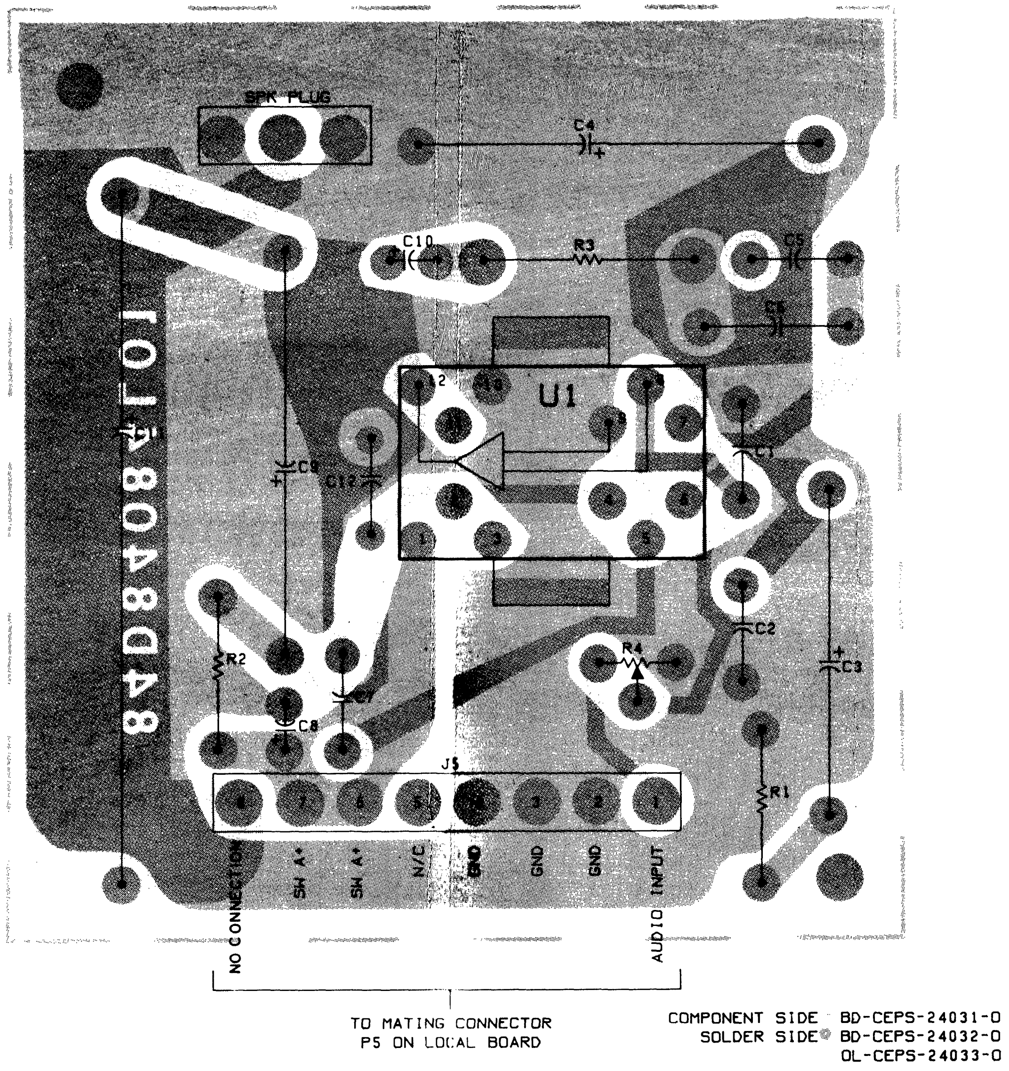
⬇	THEORY OF OPERATION DATA
⇩	MAINTENANCE DATA
―▶―	PRIMARY AUDIO SIGNAL FLOW

3 WATT AUDIO BOARD

MODEL TRN6824A

FUNCTION

Provides audio amplification for the local speaker.



SHOWN FROM COMPONENT SIDE

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THEORY OF OPERATION

1. TRANSMIT VOICE CHANNEL

The handset is plugged into the handset connector J2.

The dc supply for the microphone is taken from the VD (battery) supply and switched by Q3 so that current for the handset is only drawn from VD during the time PTT is active low.

The PTT signal from the handset is connected to C7; when the PTT switch is pressed, this side of C7 is connected to ground and instantaneously the other side of C7 also goes to ground potential. This change in potential switches U3A output high, which turns on transistor Q3, thus enabling the microphone and also enabling analog switches U2A and U2B.

C7 is now charged via R10 to Vcc and when the potential has risen above the high logic input level for U3A, U3A output goes low switching off the microphone and disabling U2A, U2B.

The time constant of R10, C7 gives a transmission time of about 30s regardless of how long PTT on the handset is pressed. When the PTT switch on the handset is released, C7 is recharged via R15 on a very short time constant, thus resetting the circuit for the next time.

The microphone signal is amplified by U4A which has a gain of about X6 (set by the ratio R5 to R7) and bandwidth limited to about 4kHz (set by C4, R5 and R7).

The amplified signal from the output of U4A is transferred to the bus connector FST via U2A. The transmit level is preset by R2, R4 together with the input impedance of the radio, to be suitable for the specified type of radio. JU6 in position B takes the output signal from potentiometer R3 (transmit level).

The handset PTT signal is also fed out to the user connector Channel Request (J3-1). The same pin is used by an external control signal in order to switch on the voice transmit channel.

The output of U3A switches U2B from ground (U2B-2) to Vcc (U2B-1), switching on transistor Q1 and making PTT on the bus connector low. The same signal from U3A switches U2A from being disconnected (U2A, pins 12 to 14), to being connected to the output of JU6 (U2A, pins 13, 14).

The input of U3B is connected to Channel Disable on the user connector (J3-2). If this pin is not connected, R12 sets U3B input high giving U3B output low which enables all sections of U2. If the Channel Disable input is taken low, U3B output goes high taking U2B-6 high; this in turn open-circuits all three sections of U2, thus completely disconnecting the voice channel.

2. RECEIVE VOICE CHANNEL

The bus connector FSR signal (the receive signal from the radio) is fed

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via U1B to amplifier U4D, when CM on the bus connector is low (U1B pin 15-2). When CM is high, the amplifier input is grounded (U1B-1).

Amplifier U4D has a variable gain which is set by volume control R37 and its bandwidth is limited to about 4kHz (set by R37, C31, R38). The amplified signal from the U4D output is fed to analog switch U2C.

The external audio amplifier positive supply voltage (if present) at pin 4 of the user connector (J3) provides a high level to pin 9 of U2C, which connects the input (pin 4) to pin 3.

Diode CR6 together with R42 limits the voltage on pin 9 to Vcc. Diode CR7 protects the audio amplifier against reversed polarity of the external power supply. When there is no external power supply for the audio amplifier, R40 provides a low level at U2C pin 9, thus switching the audio signal through to pin 5 and via C32 to the handset.

For information on the optional audio amplifier see 68P02954G82.

3. EXTERNAL RADIO INTERFACE

The bus connector (J1) PTT signal is fed out via CR2 to the external radio PTT connection (pin 10 on the user connector J3); CR2 ensures that whilst the internal PTT can pull the common external radio PTT low, other MRU systems which may also be connected to the same external radio will not affect the internal PTT signal. If there is no internal PTT signal, this line is pulled high by R19. Certain MRU modules give a PTT high signal of VD (battery), then R16 and CR1 clamp the input voltage to U1A so that it cannot exceed Vcc.

The FST bus connector signal is fed out via U1A to the external radio FST connection (pin 9 on the user connector).

U1A is enabled by the internal PTT signal.

Connecting JU3 feeds PTT through to CM if this capability is not provided by the external radio.

The CM signal from the external radio (user connector pin 5) is fed via R34 to inverter U3E and JU4. If the external CM signal cannot go above +5 V, R34 is not needed and is shorted by JU5; otherwise, R34 together with CR5 clamp the CM voltage to Vcc.

If the external radio provides an active high CM signal, then JU4 is set to position A and the signal inverted to the normal active low state; otherwise, JU4 is set to position B. When CM is low, U3F output is high causing the green LED DS1 to light. LED DS1 is also lit by CM from an internal radio.

If the external radio does not provide a CM signal, then the FSR signal from the radio is fed into amplifiers U4B and U4C via potentiometer R20.

The output of U4C is ac coupled by C24 and R28 to the base of Q2.

The base emitter junction of Q2 acts as a diode and rectifies the output signal. The rectified signal is amplified by Q2 and negative going pulses are produced at the Q2 collector. These pulses are integrated by R32 and C25 to give a mean dc level at the input of U3C. If there is no FSR signal, Q2 is cut off and the mean dc level will be Vcc, giving U3C output low and U3D output high. Potentiometer R20 (threshold) is adjusted so that the amplitude of the negative-going pulses at the Q2 collector, after integration, give a logic low level at U3C input; this in turn gives a logic low output from U3D which is the required CM signal. R32 and C25 also set the delay (attack time) between the start of FSR and CM going low. The delay at the end of CM (decay time) is set by R31 and C25.

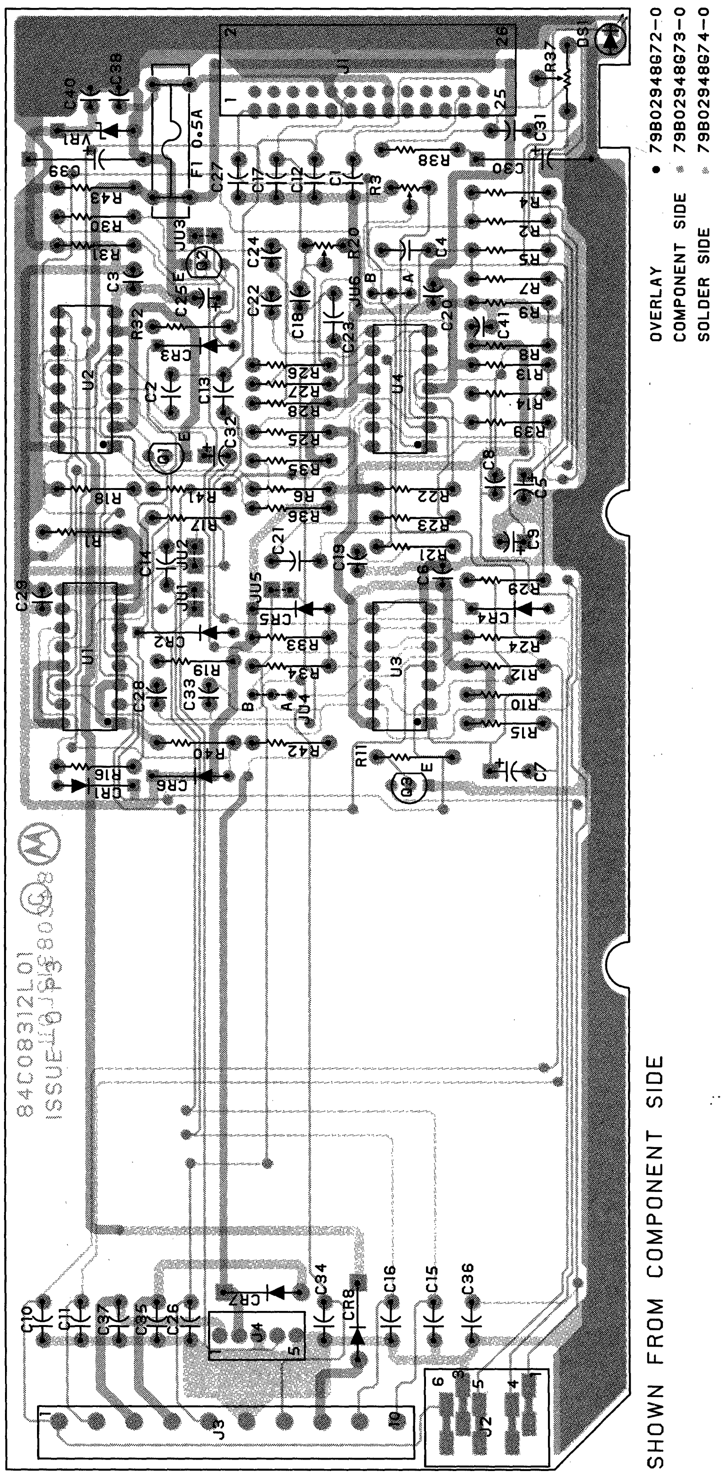
4. SHARED RADIO

Shared radio operation connects several separate MRUs to one common radio. If the common radio is an internal MRU radio, then the single VRI module connected to that radio operates in the shared radio mode. VRI modules in other MRUs continue to operate in the external radio mode.

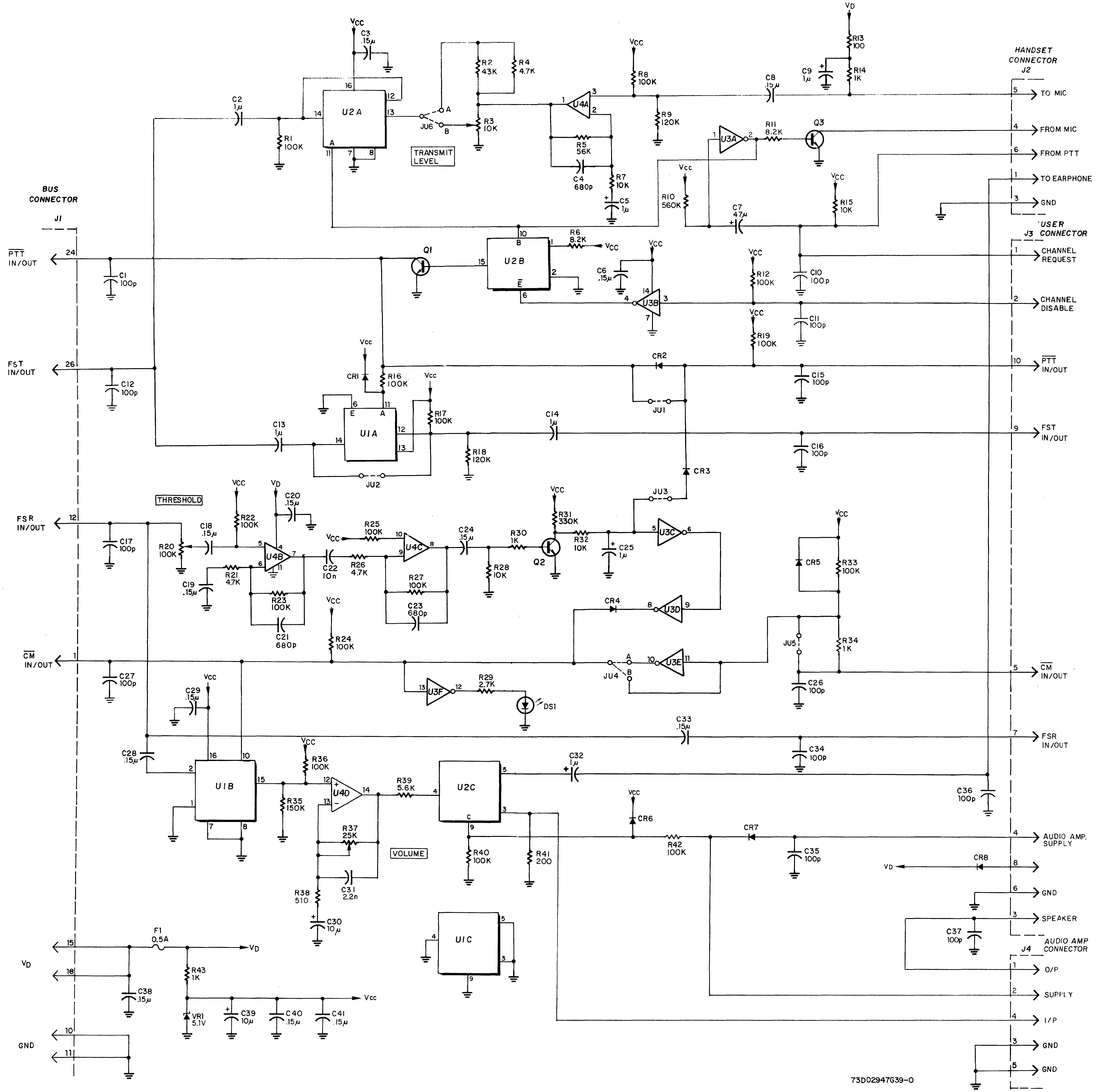
JU1 on the shared radio VRI module is connected, shorting CR2, so that external PTT signals on the user connector (J3-10) can pull down the internal PTT signal on the bus connector (J1-24).

When no PTT signal is connected to the user connector, the bus connector PTT signal is held high (to Vcc) by R19.

Resistor R16, together with CR1, limits the PTT high level signal on U1A to Vcc.


OVERLAY ● 79B02948G72-0
COMPONENT SIDE 79B02948G73-0
SOLDER SIDE 79B02948G74-0
SHOWN FROM COMPONENT SIDE
84C08312L01
ISSUE-0
F1 0.5A
J1
J2
J3
U1
U2
U3
U4
Q1
Q2
Q3
DS1

FLN4636A VRI Main Board
Printed Circuit Board Detail
August, 1987



FLN4636A VRI Main Board
Schematic Diagram
August, 1987

parts lists

FLN4636A VRI Main Board PL-0647-O

Reference Symbol	Motorola Part No.	Description
		Capacitor
C1	21-11014H49	100 pF 100V 5%
C2	21-08029H07	1 uF 50 V 10%
C3	21-84008H03	.15 uF 50V -20+80%
C4	21-83596E17	680 pF 500V 10%
C5	23-83441B29	1 uF 20 V 20%
C6	21-84008H03	.15 uF 50V -20+80%
C7	23-84538G06	47 uF 20V 20%
C8	21-84008H03	.15 uF 50V -20+80%
C9	23-83441B29	1 uF 20V 20%
C10 thru C12	21-11014H49	100 pF 100V 5%
C13, C14	21-08029H07	1 uF 50 V 10%
C15 thru C17	21-11014H49	100 pF 100V 5%
C18 thru C20	21-84008H03	.15 uF 50V -20+80%
C21	21-83596E17	680 pF 500V 10%
C22	21-05457G08	10 nF 50V 10%
C23	21-83596E17	680 pF 500V 10%
C24	21-84008H03	.15 uF 50V -20+80%
C25	23-83441B29	1 uF 20V 20%
C26, C27	21-11014H49	100 pF 100V 5%
C28, C29	21-84008H03	.15 uF 50V -20+80%
C30	23-84762H03	10 uF 20V 10%
C31	21-05457G13	2.2 nF 63V 10%
C32	23-83441B29	1 uF 20V 20%
C33	21-84008H03	.15 uF 50V -20+80%
C34 thru 37	21-11014H49	100 pF 100V 5%
C38	21-84008H03	.15 uF 50V -20+80%
C39	23-84762H03	10 uF 20V 10%
C40, C41	21-84008H03	.15 uF 50V -20+80%
		Diode
CR1	48-11034A01	1N4148
CR2	48-84616A01	HPA5082-2877
CR3 thru CR6	48-11034A01	1N4148
CR7, CR8	48-82466H13	silicon
		LED
DS1	48-84404E04	green
		Fuse
F1	65-02069C22	0.5 A 250 V
		Connector
J1	28-08044H06	26-pin bus conn
J2	28-84269C01	handset conn pin (lo; 2 used)
	28-84269C02	handset conn pin (hi; 3 used)
J3	28-08508G19	10-pin user conn
J4	28-02208K09	5-pin audio amp conn
		Jumper
JU1	28-02218K12	jumper header 2-pin
JU2	-----	not used
JU3	28-02218K12	jumper header 2-pin
JU4	28-82622L01	jumper header 3-pin
JU5	28-02218K12	jumper header 2-pin
JU6	28-82622L01	jumper header 3-pin
	29-02219K01	mini jumper; 5 used

FLN4636A VRI Main Board PL-0647-O

Reference Symbol	Motorola Part No.	Description
		Transistor
Q1 thru Q3	48-02089C17	NPN; 2N4124
		Resistors:fixed ±5% 1/4W unless stated otherwise
R1	06-11009C97	100k
R2	06-11009C88	43k
R3	18-02467C22	10k potentiometer
R4	06-11009C65	4.7k
R5	06-11009C91	56k
R6	06-11009C71	8.2k
R7	06-11009C73	10k
R8	06-11009C97	100k
R9	06-11009C99	120k
R10	06-11009D16	560k
R11	06-11009C71	8.2k
R12	06-11009C97	100k
R13	06-11009C25	100
R14	06-11009C49	1k
R15	06-11009C73	10k
R16, R17	06-11009C97	100k
R18	06-11009C99	120k
R19	06-11009C97	100k
R20	18-02467C36	100k potentiometer
R21	06-11009C65	4.7k
R22 thru R25	06-11009C97	100k
R26	06-11009C65	4.7k
R27	06-11009C97	100k
R28	06-11009C73	10k
R29	06-11009C59	2.7k
R30	06-11009C49	1k
R31	06-11009D10	330k
R32	06-11009C73	10k
R33	06-11009C97	100k
R34	06-11009C49	1k
R35	06-11009D02	150k
R36	06-11009C97	100k
R37	18-83083G03	25k potentiometer
R38	06-11009C42	510
R39	06-11009C67	5.6k
R40	06-11009C97	100k
R41	06-11009C32	200
R42	06-11009C97	100k
R43	06-11009C43	1k
		Integrated Circuit
U1, U2	51-08244G64	triple analog switch
U3	51-83808P10	hex schmitt trigger inv
U4	51-02116C18	quad op amp
		Zener Diode
VR1	48-08322H03	5.1 V, 250 mW
	Non Referenced Items	
	22-90003700	captive nut; 2 used
	42-02226C04	fuse holder; 2 used
	84-08310L01	spacer board (for J2)
	84-08312L01	printed circuit board

FLN4638A VRI Label Kit PL-0648-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced items	
	54-08124H15	address label
	54-08635G24	front panel label

FLN4637A VRI Hardware Kit PL-0649-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	01-02717G06	terminal and wire assembly includes:
	29-02231C07	terminal lug; 2 used
	03-00129675	lock screw, 4-40 x 1/4"; 2 used
	03-00134309	lock screw, 4-40 x 3/16"
	31-08509G15	terminal with socket
	54-08125H01	user connector label

FLN4347A VRI Housing PL-0650-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	02-02427C01	lock nut 4x40
	03-08026H05	captive screw 8x32 7/8"; 2 used
	03-82210E15	captive screw; 2 used
	15-08513H01	housing bottom
	15-08586G01	housing cover
	15-08587G01	housing door
	22-02482C02	dowel pin

NOTE: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

INTRAC 2000
Modular Remote Unit
Voice and Radio Interface

68P02943G15-O

MOTOROLA INC.
*Communications
Sector*

BUS EXPANSION INTERFACE

Model FRN1767A

1. GENERAL DESCRIPTION

The Bus Expansion Interface (BXI) enables expansion of the AMRU and MRU in a 19" mounting rack (Master) beyond the physical limitations of its chassis. With the BXI module, a second chassis (Slave) can be installed and connected near the AMRU or MRU in a 19" mounting rack, thus enabling the expansion of the system.

The expansion unit must also include a BXI module which is physically connected to the BXI module in the AMRU or MRU in 19" mounting rack via an expansion bus cable.

A 4-position DIP switch enables connection/disconnection of radio signals (FSK Tx, FSK Rx, PTT, CM) from the 40-pin cable. The default and recommended position is disconnection.

2. EXPANSION CONNECTION

A 40-pin cable, (FKN5769A) maximum length 0.5 m (19 2/3"), connects the two BXI modules in the master and slave AMRU (or the MRU in 19" mounting rack) units.

3. INSTALLATION

Both chassis should be mounted one above the other. They are connected by the BXI modules (one mounted on the Master unit the other on the Slave unit) via a 40-pin twisted flat cable. The maximum cable length should not exceed 0.5 m.

One BXI module is configured with the Slave (AMRU without MRI, Encoder and Decoder) unit (option V026). The other BXI module is configured with the Master (AMRU with MRI, Encoder and Decoder) unit. Use the FKN5710A cable to connect the BXI module to the AMRU bus in place of the existing flat cable in the AMRU. Both BXI modules must be located on the left most position on the chassis; see the figure below.

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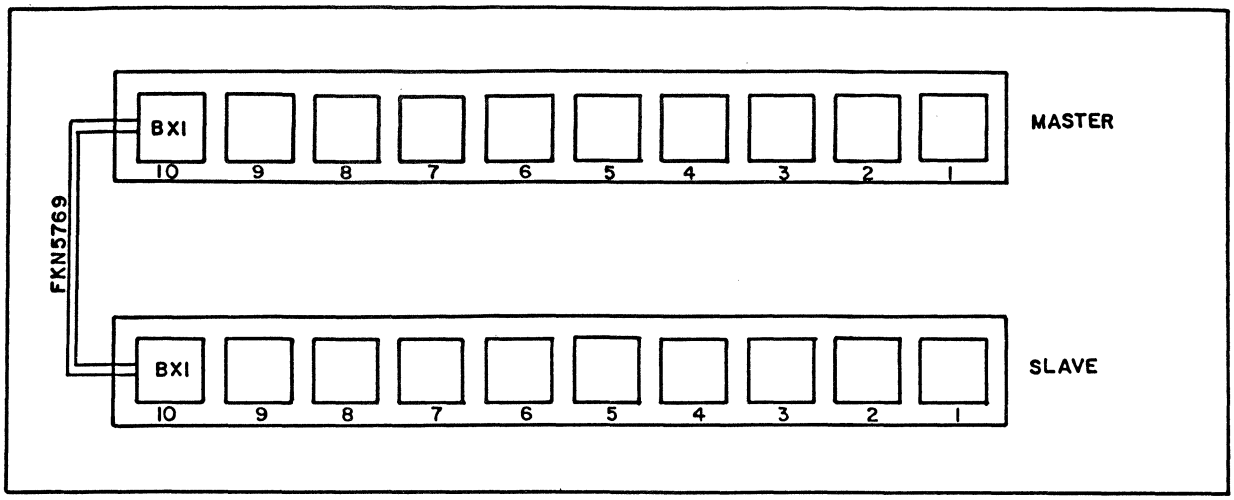
4. MODEL COMPLEMENTS AND OPTION

FRN1767A Bus Expansion Interface

FLN4899A	BXI PC board
FLN4900A	Label Kit
FLN4347A	Housing
FLN4901A	Hardware Kit

Option V026AA Slave AMRU

add:	FRN1767A	Bus Expansion Interface (BXI); 2 used
	FKN5710A	10 Module Flat Cable
	FKN5769A	Interface Cable
delete:	FLN1477A	Microwave Radio Interface (MRI)
	FRN1668A	MRU Encoder Assembly
	FLN1453A	Decoder Module (DC-4)



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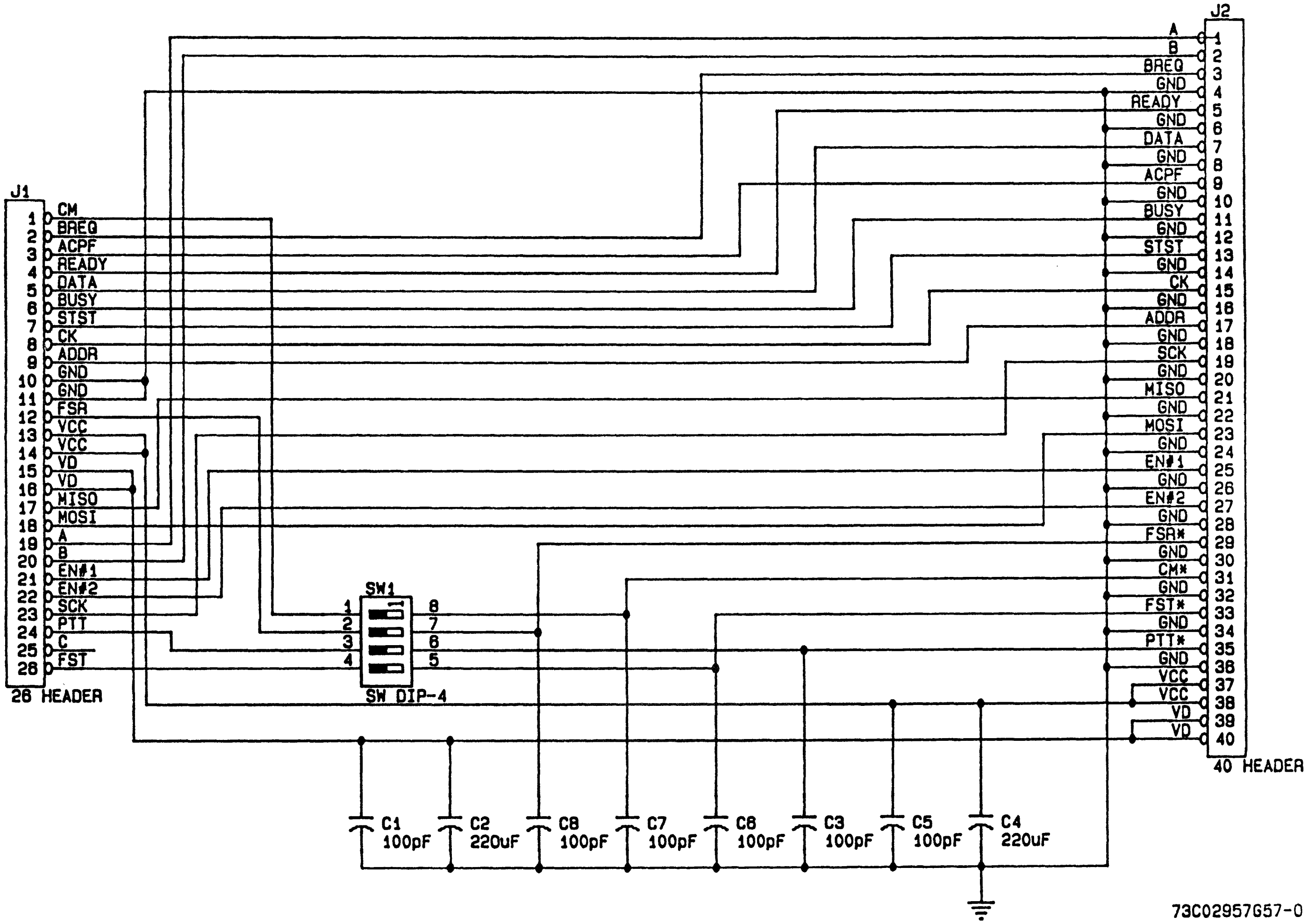
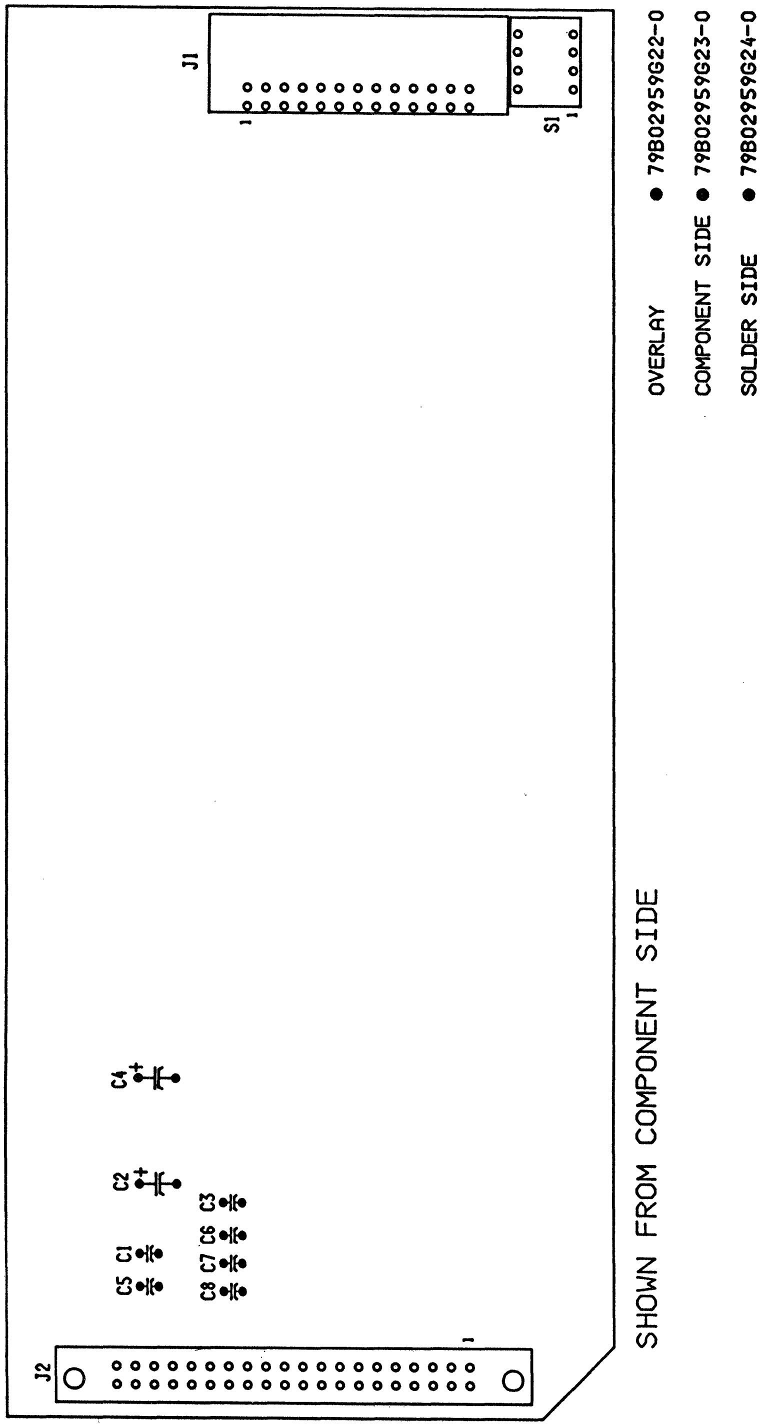
AMRU or MRU in 19" Mounting Rack System With BXI



BXI Interface
Schematic Diagram
March, 1988



J1
1
S1
1
OVERLAY ● 79B02959G22-0
COMPONENT SIDE ● 79B02959G23-0
SOLDER SIDE ● 79B02959G24-0
SHOWN FROM COMPONENT SIDE
C4
+
C2
+
C3
C6
C7
C8
C1
C5
J2
1

BXI Interface
Printed Circuit Board Detail
March, 1988

parts lists

FLN4899A BXI Printed Circuit Board PL-0734-O

Reference Symbol	Motorola Part No.	Description
		Capacitor
C1	21-05455G01	100 pF
C2	23-02166L07	220 uF; 50 V
C3	21-05455G01	100 pF
C4	23-02166L07	220 uF; 50 V
C5 thru C8	21-05455G01	100 pF
		Connector
J1	28-08044H06	26-pin connector
J2	28-02428C13	40-pin connector
		Switch
SW1	40-83849F04	DIP switch 4 positions
	Non Referenced Item	
	84-02214S01	Printed circuit board

FLN4900A Label Kit PL-0735-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Item	
	54-08635G25	BXI label
	54-08124H17	BXI door label
	54-02443L01	FCC label
	54-02211801	Serial number label

FLN4347A Housing PL-0736-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Item	
	01-08028L01	plastic housing

FLN4901A Hardware Kit PL-0737-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Item	
	01-02717G06	Terminal & wire
	03-00129675	Lockscrew 4x40x1/4; 2 used
	03-00134309	Lockscrew 4x40x3/16

FKN5769A Interface Cable PL-0738-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Item	
	30-08561C01	Flat cable 40 wires
	09-02136C23	40-pin connector; 2 used

MOTOROLA INC.
Communications
Sector

instruction manual revision

GENERAL

This revision details changes that apply to your instruction manual. Please update your manual accordingly.

INSTRUCTION MANUAL AFFECTED

68P02938G05-O Wireline Interface Module Instruction Manual

REVISION DETAILS

The FLN1467A Wireline Interface has been modified, enabling it to operate with an external radio with low impedance at the TX input (600 ohm) and with both CM polarities, active low and active high. Consequently, the updated model number is FLN1467B. The following modifications have been performed:

1. Integrated circuit U8 is replaced by 4741 quad op amp (51-02162C18).

2. JU2 is a header with a mini jumper to select the desired CM polarity:
   C to A - active low
   C to B - active high
   The default setting is C to A active low.

3. Jumper JU12 is added to select 1 uF capacitor (21-08029H07), in parallel to C12, for low impedance at FSK TX to the radio. JU12 and the capacitor are installed on the PC board between J2 and R13.

   JU12 jumpered - low impedance (down to 600 ohm)
   JU12 not jumpered - high impedance (for HT-90/440 radios)
   The default setting is jumpered for low impedance.

4. A 510 kohm resistor is added in series with C41 to delay the PTT to the radio for about 20 msec and enable the AGC to stabilize before the TX signal is transmitted.

Parts List

a. Add the following parts to the parts list:

U8	51-02162C18	4741 (instead of 51-83629M18)
C58	21-08029H07	1uF capacitor
R56	06-11009D15	510 k 5% resistor
JU2	28-82622L01	3-pin header
	29-02219K01	mini jumper
JU12	28-02218K12	2-pin header
	29-02219K01	mini jumper

The PC board is ISSUE-A

b. Delete the following parts from the parts list:

U8	51-83629M18	LM-224

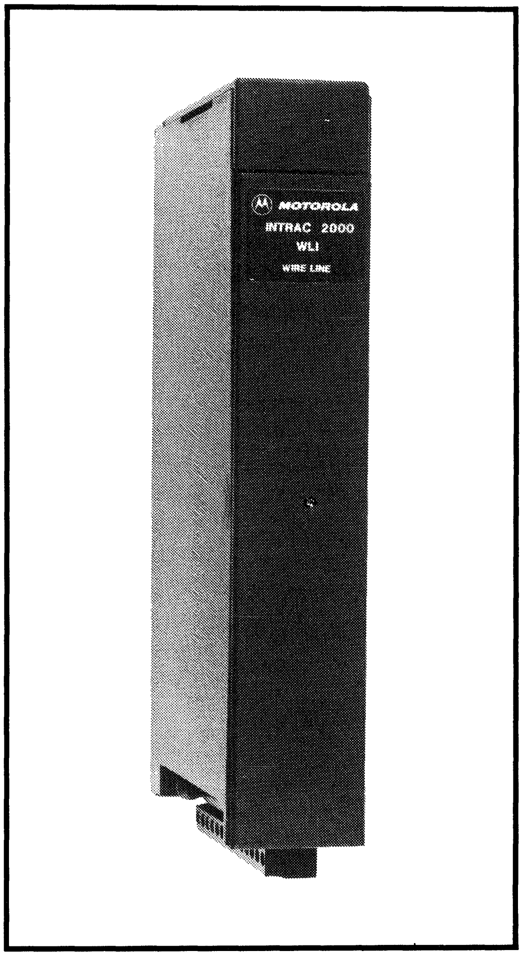
System Configuration

If the Wireline Interface is to be connected to the following radios, set the jumpers as indicated:

HT-90/440 - JU12 not jumpered
DARCOM - JU2 C to B
MAXTRAC - JU2 C to B
MAXAR - JU2 C to B

MOTOROLA

INTRAC 2000™
Modular Remote Unit Wireline Interface



Instruction Manual

68P02938G05-O

COMMERCIAL WARRANTY
(STANDARD)

Motorola radio communications products are warranted to be free from defects in material and workmanship for a period of ONE (1) YEAR, (except for crystals and channel elements, which are warranted for a period of ten (10) years) from the date of shipment. Parts, including crystals and channel elements, will be replaced free of charge for the full warranty period, but the labor to replace defective parts will only be provided for One Hundred-Twenty (120) days from the date of shipment. Thereafter, purchaser must pay for the labor involved in repairing the product or replacing the parts at the prevailing rates together with any transportation charges to or from the place where warranty service is provided. This express warranty is extended by Motorola Communications and Electronics, Inc., 1301 Algonquin Road, Schaumburg, Illinois 60196, to the original purchaser only, and only to those purchasing for purpose of leasing or solely for commercial, industrial, or governmental use.

THIS WARRANTY IS GIVEN IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, WHICH ARE SPECIFICALLY EXCLUDED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL MOTOROLA BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW.

In the event of a defect, malfunction or failure to conform to specification established by SELLER, or if appropriate, to specifications accepted by Seller in writing, during the period shown, Motorola, at its option, will either repair or replace the product or refund the purchase price thereof, and such action on the part of Motorola shall be the full extent of Motorola's liability hereunder.

This warranty is void if:

a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage; and/or
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

The warranty extends only to individual products; batteries are excluded. Because each radio system is unique, Motorola disclaims liability for range, coverage, or operation of the system as a whole under this warranty except by a separate written agreement signed by an officer of Motorola.

LICENSED PROGRAMS: Motorola software provided in connection with this order is warranted to be free from reproducible defects for a period on ONE (1) YEAR. All material and labor to repair any such defects will be provided free of charge for the full warranty period, and SUBJECT TO THE DISCLAIMER IN BOLDFACE TYPE.

Non-Motorola manufactured products are excluded from this warranty, but are subject to the warranty provided by their manufacturers, a copy of which will be supplied to you on specific written request.

In order to obtain performance of this warranty, purchasers must contact their Motorola sales person or Motorola at the address first above shown, attention Quality Assurance Department.

This warranty applies only within the United States.

EPS-30831-O

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EPS-34440-A

MOTOROLA INC.
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INTRAC 2000™
Modular Remote Unit
Wireline Interface

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FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar equipment. The information it contains is current as of the printing date. Subsequent engineering changes are described in supplementary Instruction Manual Revisions (IMRs) issued as needed. The applicable schematic diagram is updated and the changes are described in a revision column printed either on the diagram or next to the corresponding parts list.

2. SERVICE

The Motorola National Service Organization offers one of the finest nationwide installation and maintenance programs available to communications equipment users. This organization comprises approximately 900 Motorola Service Stations located throughout the United States. Each Service Station is independently owned and operated, is staffed by one or more trained, FCC-licensed technicians, and is specially selected and authorized by Motorola.

The administrative staff of the National Service Organization consists of national, area and district service managers, and district representatives, all of whom are Motorola employees. Their objective is continually to improve the service to Motorola customers.

Motorola maintenance is available either on a time and material basis, or by means of a service contract. To obtain a service contract, contact your Motorola Service Representative, or write to:

National Service Manager
Motorola Communications and Electronics Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

3. MODEL AND KIT IDENTIFICATION

Every Motorola product is specifically identified by an overall model number printed on the nameplate. In addition, the assemblies and kits comprising the product usually have kit model numbers stamped on them.

4. REPLACEMENT PARTS ORDERING

Motorola maintains a **factory parts center** and several **area parts centers** located throughout the United States. These facilities are equipped to process parts orders, identify part numbers, and otherwise assist in the maintenance and repair of Motorola Communications Group products. The addresses of these parts centers are listed on the following page.

Orders for crystals, channel elements, active filters, PROMs, code plugs, and resonant reeds should be

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sent directly to the **factory parts center.** Orders for all other parts and for instruction manuals should be sent to the nearest **area parts center.**

All orders for replacement parts or equipment information should include the complete identification number. This requirement applies to all components, kits and chassis. If the component part number is not known, the order should include the number of the chassis or kit which uses it, and a description of the desired component sufficient to identify it.

Orders for crystals and channel elements should specify the crystal or channel element type number, crystal and carrier frequencies, and the model number of the chassis using the part.

Orders for active filters, PROMs, code plugs, and "Vibrasender" and "Vibrasponder" resonant reeds, should specify type number and frequency, and should identify the owner/operator of the communications system utilizing these items.

5. ADDRESSES

5.1 AREA PARTS CENTERS

5.1.1 U.S. Orders

Western Area Parts
1170 Chess Drive, Foster City
San Mateo, California 94404
Telephone: 415-349-3111
TWX: 910-375-3877

Midwest Area Parts
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-7322
TWX: 910-693-0869

Mid-Atlantic Area Parts
7230 Parkway Drive
Hanover, Maryland 20176
Telephone: 301-796-8600
TWX: 710-862-1941

East Central Area Parts
12995 Snow Road
Parma, Ohio 44130
Telephone: 216-267-2210
TWX: 810-421-8845

Eastern Area Parts
85 Harristown Road
Glen Rock, New Jersey 07452
Telephones: 201-447-4000
TWX: 710-988-5602

Pacific Southwestern Area Parts
P.O. Box 85036
San Diego, California 92138
Telephone: 714-578-2222
TWX: 910-335-1634

Gulf States Area Parts
8550 Katy Freeway, Suite 128
Houston, Texas 77024
Telephone: 713-932-8955

Southwestern Area Parts
P.O. Box 34290
3320 Belt Line Road
Dallas, Texas 75234
Telephone: 214-241-2151
TWX: 910-860-5505

Southeastern Area Parts
P.O. Box 368
Decatur, Georgia 30031
Telephone: 504-981-9800
TWX: 810-766-0876

5.1.2 Canadian Orders

Motorola Ltd.
National Parts Department
3125 Steeles Avenue
E. Willowdale, Ontario M2H 2H6
Telephone: 416-499-1441
TWX: 610-492-2713
Telex: 065-25191

5.1.3 All Other Countries

Motorola Inc., or
Motorola Americas, Inc.
International Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
U.S.A.
Telephone: 312-576-6492
TWX: 910-693-0869
Telex: 722443 or 722424
Cable: MOTOL PARTS

5.2 FACTORY PARTS CENTER

5.2.1 Mail Orders

Motorola, Inc.
Component Products Sales and Service
P.O. Box 66191
O'Hare International Airport
Chicago, Illinois 60666

5.2.2 Other Correspondence

Motorola, Inc.
Component Products Sales and Service
2553 N. Edgington Street
Franklin Park, Illinois 60131

5.3 GENERAL OFFICES

Motorola Communications and Electronics Inc.
Communications Group Parts Dept.
1303 E. Algonquin Road
Schaumburg, Illinois 60196
Telephone: 312-576-3900

KIT BREAKDOWN

FLN1467A Wireline Interface Module (WLI)

- FLN4422A Main Board
- FLN5720A Hardware Kit
- FLN4504A Label Kit
- FLN4347A Modular Housing

PERFORMANCE SPECIFICATIONS

GENERAL

Power Input	One of the following possibilities: - AC 22-28V 50/60 Hz 3 VA max. - DC with internal nicad battery, 22-28V dc 0.1 amp. max. - DC without internal battery 11-15V dc. Nominal current consumption 5 mA.
Operating Temperature	-30°C to +60°C.
Relative Humidity	0-90% without condensation.
Housing	Thermo-plastic module.
Dimensions	1.6" X 8.3" X 3.7" (H x W x D) 40.64 X 210.82 X 93.98mm Height with open door 11.6"
Weight	1 lb (0.454 kg)
Configurations	With MRU less radio With radio only With MRU and radio With Central Station.
FSK from MRU/Radio	0.1V to 2V rms. 10k ohm input impedance.
FSK to MRU/Radio	50 mV to 160 mV rms. 20k ohm output impedance 130 mV Nominal (AGC).
Frequency range	300 to 3400 Hz

LINE

Line configuration	2 wire only
Line impedance	600 ohms or high impedance
Reflection coefficient	> 16 dB
Impedance balance ratio	> 56 dB

Input signal level	-35 to + 10 dBm Automatic Gain Control
Output signal level	-15 to +6 dBm
DC output level	11-15 V dc to the line, 25 mA max.

CHANNEL MONITOR (CM)

Channel Monitor actuation	a. Tone detection, LED indication 900 and 1500 Hz -35 to +10 dBm adjustable with adjustable noise threshold for voice detection. b. DC voltage on line, LED indication 7.5 to 15 V (5 mA max) 3k V dc isolation. c. External input VIL ÷ 0.8V VIH ÷ 2.4V active high or low jumper selectable surge protected.
Channel Monitor output	open collector, active high or active low, jumper selectable. V max 50 V I max 250 mA

PUSH TO TALK (PTT)

Push-to-talk actuation (same as CM)	a. Tone detection b. DC voltage on line c. External input, active low.
Push-to-talk output	a. Open collector active low V max 50 V I max 250 mA b. Dry contact (250 V 1 A)

SURGE PROTECTION

Line transformer isolation	500 V dc
Line surge protection	IEEE 472 standard, 3k V. Capacitor discharge, 25 uF 600 V

MOTOROLA INC.
Communications Sector

SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.
2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.
3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.
5. Use only a grounded soldering iron.
6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

WARNING

If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.

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Communications Sector

GENERAL DESCRIPTION

1. GENERAL

The Wireline Interface Module (WLI) is an option (V226) of the Modular Remote Unit (MRU) family.

The function of the WLI is to enable wireline operation among INTRAC 2000 MRUs and central stations. It provides adaptation between the FSK signal transmitted by the MRU, 2-wire wireline, and the radio.

The WLI can be used both for models with radio and for models without radio. It allows simultaneous transfer of FSK signals, Channel Monitor (CM) and Push to Talk (PTT) control signals between MRU, line and radio (see Figure 1. WLI FSK Flow).

The two main configurations are:

a. Wireline systems - where several MRUs communicate with each other and/or with a central station, via a 2-wire line.

b. Radio and Wireline systems - where several wireline MRUs share one radio.

NOTE
The following references made to wireline operation of the MRU also apply to INTRAC 2000 central stations.

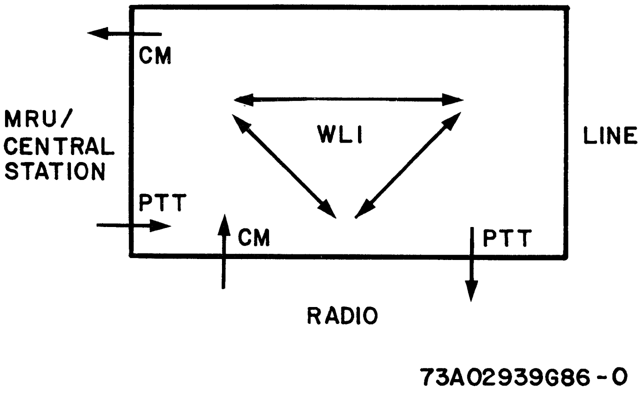

Figure 1. WLI FSK Flow

2. LINE INTERFACE

The source of FSK signals transmitted to the line is either the MRU or the signals received by the radio.

FSK signals on the line are received by the Automatic Gain Control (AGC) of the WLI and transferred to the MRU and the radio transmitter.

The tone detector detects FSK tones (900 Hz, 1500 Hz) on the line, provides the CM output to the MRU, and the PTT output to the radio transmitter.

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3. MRU/CENTRAL STATION INTERFACE

During MRU transmission, FSK signals are transferred by the WLI to the line and the radio simultaneously, together with the PTT control from the MRU.

The MRU receives FSK signals from the line **or** from the radio receiver. These signals are controlled by the Automatic Gain Control (AGC). They are transferred with the CM signal to the MRU to indicate channel busy.

The PTT signal from the MRU can be converted by the WLI to dry contacts or dc voltage on the line.

4. RADIO INTERFACE

The radio can be a standard MRU radio connected to the WLI via the radio connector, or an external radio connected through the user connector.

Signals received by the radio are transferred simultaneously to the MRU and to the line by the WLI. The CM signal from the radio acts as the control signal of the WLI.

The radio transmits FSK signals that are transferred by the WLI from the MRU or the line. The PTT signal of the WLI that controls the transmitter is a function of the PTT signal input from the MRU, the tone detector, or the dc detector.

5. DC LEVEL OUTPUT

The dc level output converts the PTT signal to a 12 V dc signal. Then the dc signal is transferred via the 2-wire line together with the FSK signal. It is detected by the dc detector of the receiving end, which enables a channel busy indication and a PTT signal to control the radio (if connected).

The dc level output can be used only on lines which permit dc continuity.

6. POWER SUPPLY

The WLI module has an onboard power supply and battery charger for configurations where it does not receive 12 V dc supply from the MRU bus. The charger is intended for the "Remote Radio" (radio only) configuration (which does not include an Encoder module containing the battery charger).

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WIRELINE CONFIGURATIONS

1. WIRELINE ONLY SYSTEM

In the wireline only system, several MRUs can communicate (with each other and/or with a central station) via a 2-wire line (see Figure 1. Wireline Only Configuration). Each MRU in the system is configured as a "wireline" MRU, i.e., MRU without radio, model (F6209) together with the WLI module (V226) option.

NOTE

The F6209/V226 does not include power supply and operates either at 12 V dc or at 24 V ac/dc. Transformers are available as accessories (FLN5879 for 115 V ac and FLN5880 for 230 V ac operation).

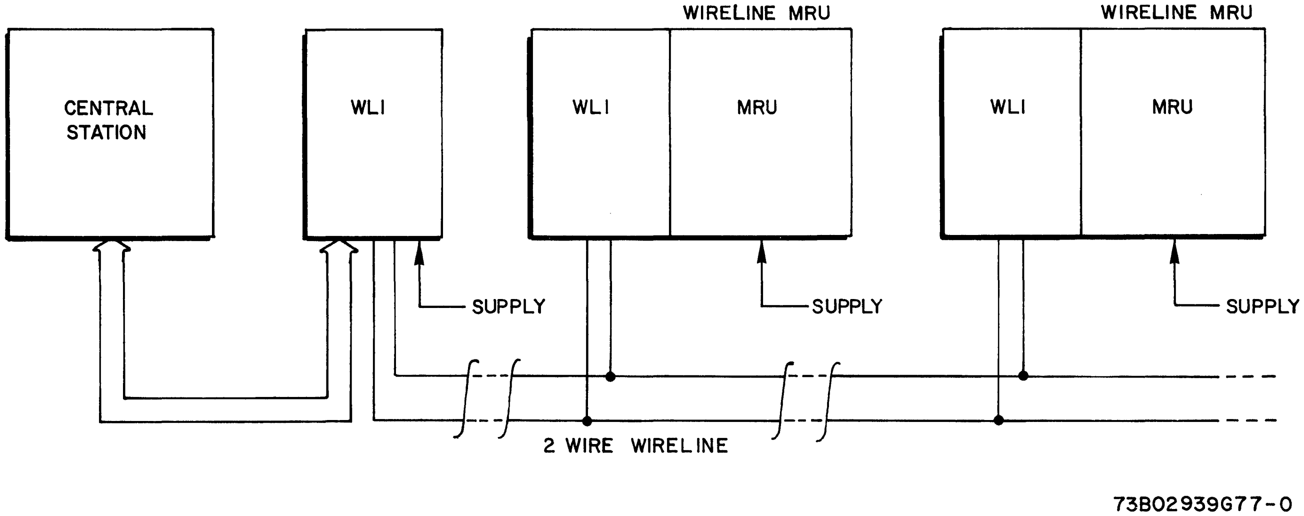

Figure 1. Wireline Only Configuration

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2. RADIO AND WIRELINE CONFIGURATION

In the radio and wireline configuration, several wireline MRUs can be connected to one radio. (See Figures 2a. Radio and Wireline Configuration with Integral MRU Radio, 2b. Radio and Wireline Configuration with External Radio and 3. Radio and Wireline MRU).

In this configuration the recommended MRU parameter settings are:

- PTT delay time, more than 200 msec.
- Word/burst, more than 2 words per burst.

2.1 REMOTE RADIO

In applications where it may be required to locate the radio at a distance from the MRUs, a suitable configuration is a "Radio-Only" MRU (see Figure 2a. Radio and Wireline Configuration with Integral MRU Radio). Alternatively, an external radio can be used instead of the MRU radio (see Figure 2b. Radio and Wireline Configuration with an External Radio). The "Radio-Only MRU" consists of a MRU radio and a WLI module (F6214 or F6223 or F6253 and option V307).

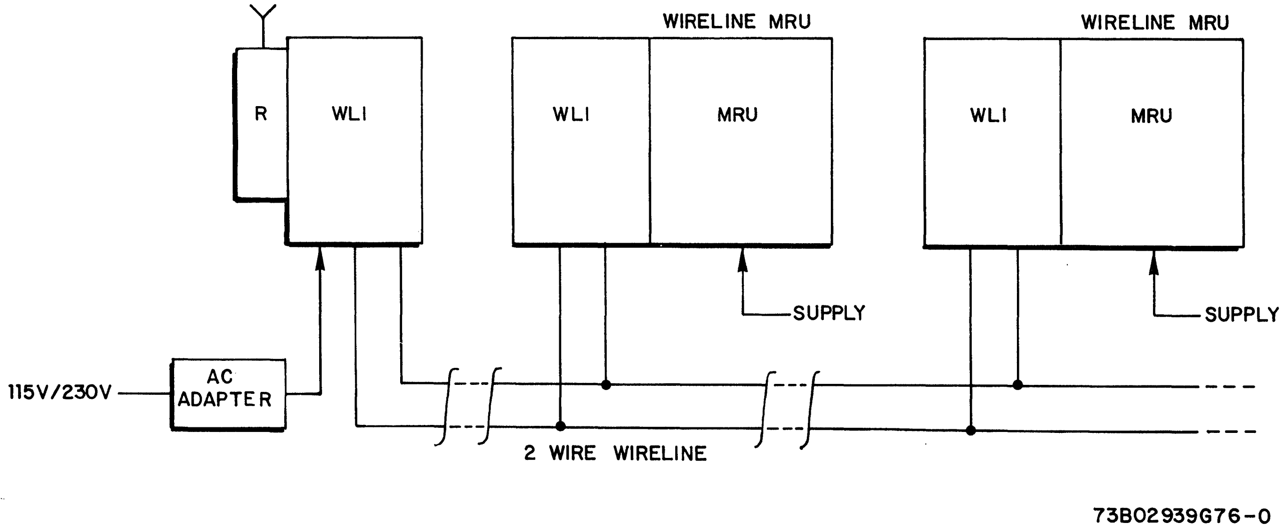

Figure 2a. Radio and Wireline Configuration with Integral MRU Radio

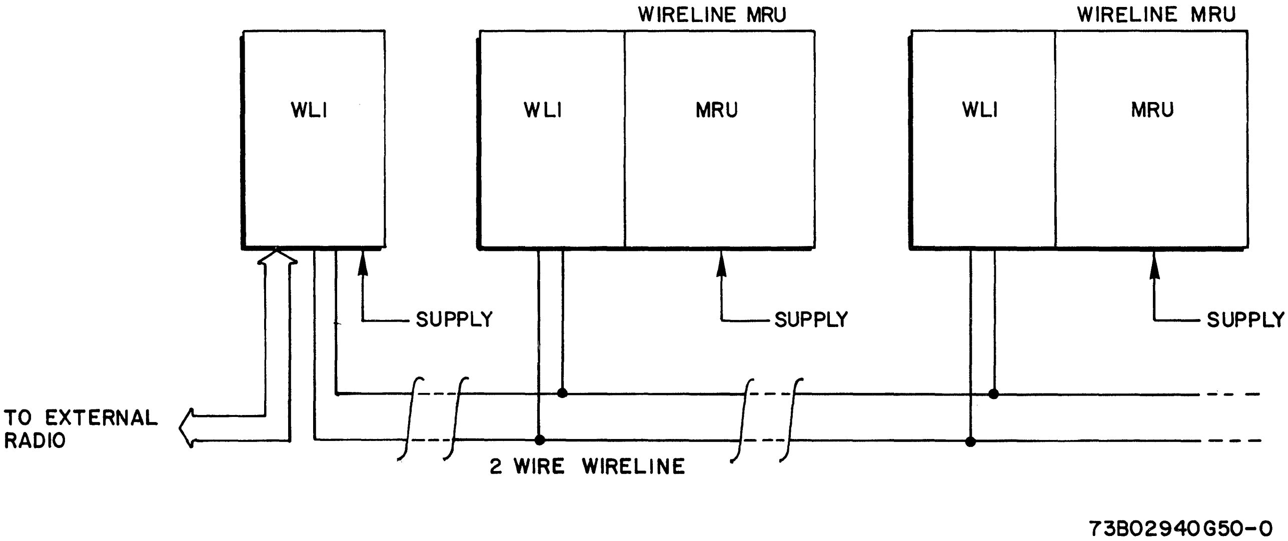

Figure 2b. Radio and Wireline Configuration with External Radio

2.2 RADIO AND WIRELINE MRUs

In some applications it may be suitable to allow several Wireline MRUs to share one "Radio and Wireline" MRU (see Figure 3. Radio and Wireline MRU). Alternatively, an external radio may be used. The "Radio and Wireline" MRU consists of a MRU with radio and a WLI module (F6214 or F6223 or F6253 and option V226).

2.3 SELECTIVE RADIO AND WIRELINE MRUs

In this application, only selected (by jumpers) Wireline MRUs have the privilege to use the radio. All others are permitted to communicate on the line only. Assigning a dc level output to the selected MRUs enables these units to indicate PTT to the radio. The "Radio and Wireline" MRU is privileged by default. It is not recommended to use this configuration where line distances are more than 1 km.

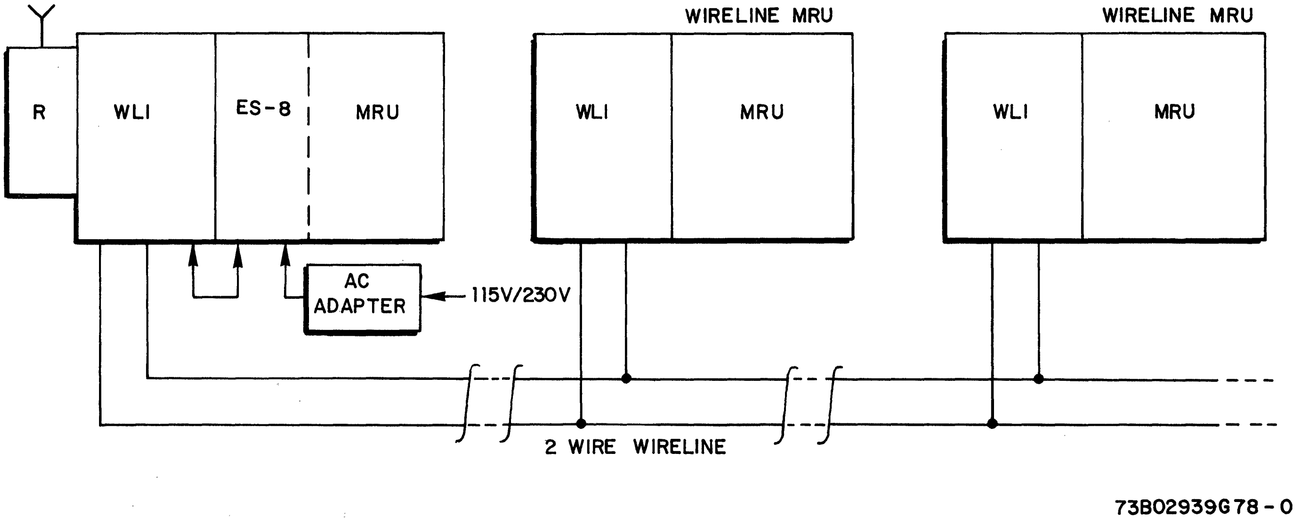

Figure 3. Radio and Wireline MRU

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INSTALLATION

1. PRELIMINARY

Carefully inspect the WLI module immediately upon receipt and notify the shipper of any damage that has ocurred in transit. The installation procedure consists of mounting the housing and making the necessary external and internal electrical connections.

2. DISASSEMBLY

To access jumpers or tune trimmers, the WLI must be disassembled. Follow the directions below for proper disassembly of the WLI housing (refer to Figure 2. Disassembly).

Step 1 Disconnect the MRU bus cable (if connected).

Step 2 Loosen the two captive screws which hold the module to the mounting plate.

Step 3 Loosen the two screws on the right panel of the WLI housing.

Step 4 Lift the latch door located at the top of the housing.

Step 5 Disconnect the radio cable (if connected to radio).

Step 6 Gently separate the two sides, the PC board is now exposed.

3. JUMPERS

3.1 GENERAL

Refer to PC Board Detail

Changing jumper settings involves delicate work on the PC board. This operation is best performed first before any connections are made to the WLI module.

WARNING

Touch the metal coating inside the housing before changing any jumper setting, to dissipate any static charge that might otherwise damage the CMOS integrated circuits.

The factory supplies the WLI module with predetermined jumpers by means of foil printed on the lower (foil) side of the printed circuit board, except for JU10 which is a mini-jumper that controls external power supply operation. These connections determine the normal (by default) operation of the WLI. To change a connection, carefully cut the foil. Then solder a short piece of bare wire between the holes in the printed circuit board. (Refer to Table 1. Wireline Interface Jumpers.)

CAUTION

Do not attempt to change the settings of jumpers intended for factory use only.

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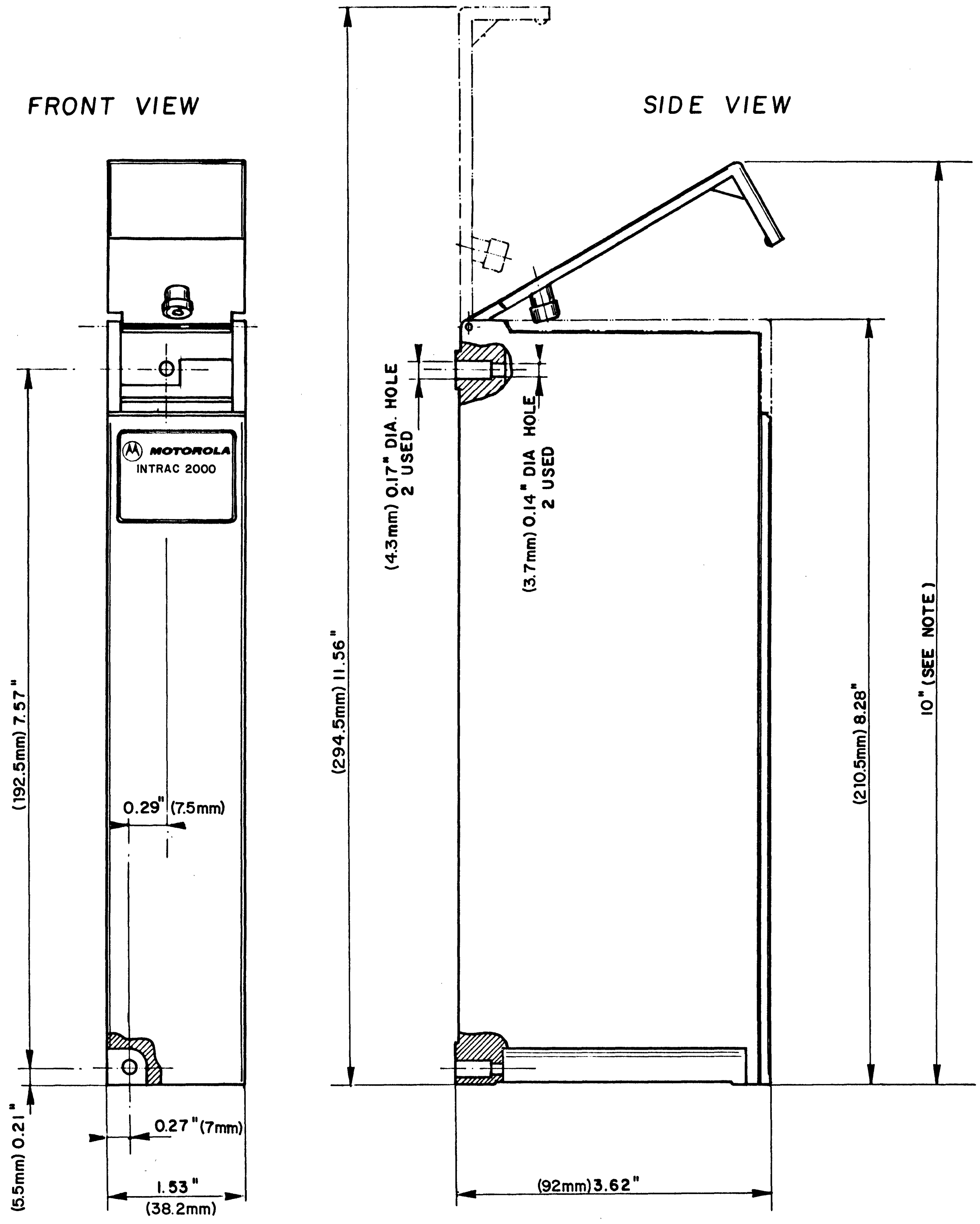

NOTE

MINIMUM OPENING FOR REMOVING WIRE CONNECTOR.

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Figure 1. Housing Detail

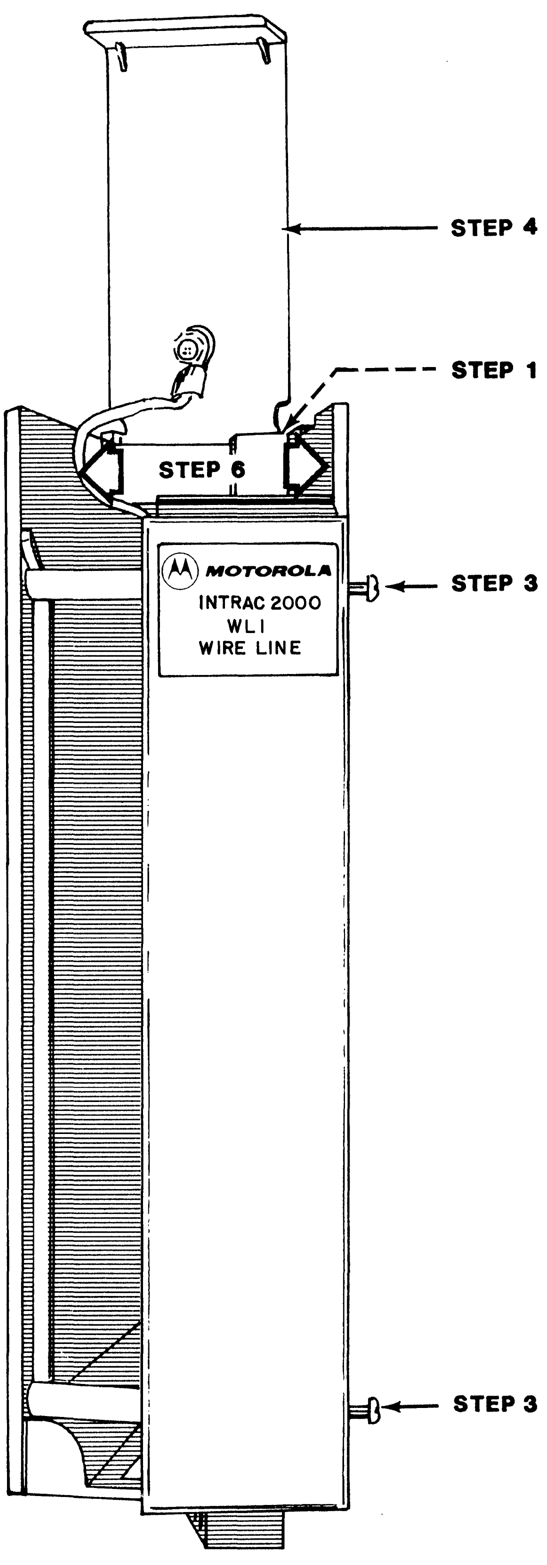

Figure 2. Disassembly

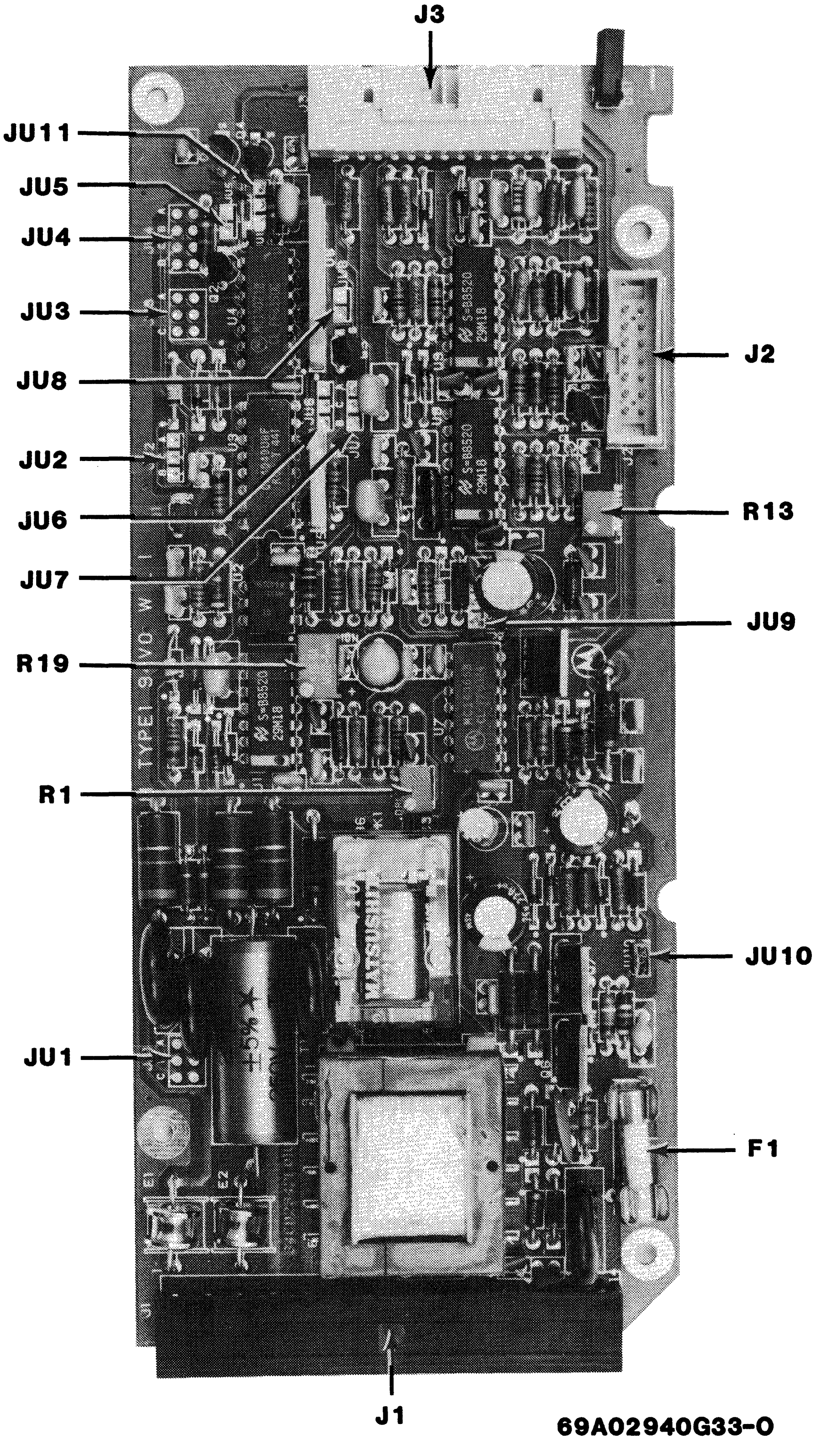

Figure 3. Wireline Board

Table 1. Wireline Interface Jumpers

JUMPER	CONNECTION	FUNCTION
JU1/A	Not connected* Connected	PTT output available as dry contact DC on-line option available
JU1/C,D	Not connected* Connected	DC on-line not available DC on-line available
JU2	C-A* C-B	CM input busy-low CM input busy-high
JU3/A	Not connected Connected*	Relay not active (for DC on-line and for PTT Relay is active as dry contact)
JU3/B	Not connected* Connected	CM out is not a function of DC detector CM out is a function of DC detector
JU3/C	Not connected Connected*	CM out is not a function of tone detector CM out is a function of tone detector
JU4/A,B	Not connected Connected*	Factory use only
JU4/C	Not connected Connected*	PTT out is not activated by tone detector PTT out is activated by tone detector
JU4/D	Not connected* Connected	PTT out is not activated by DC detector PTT out is activated by DC detector
JU5	Not connected Connected*	CM out is not activated by external CM input CM out is activated by external CM input
JU6	C-A* C-B	CM out busy-low CM out busy-high
JU7	C-A* C-B	LED indication on tone detector LED indication on DC detection
JU8	Not connected Connected*	PTT out not activated by external or MRU PTT PTT out activated by external PTT input or MRU PTT
JU9	Not connected* Connected	High impedance reflected to line during reception (10k Ohm) Low impedance reflected to line during reception (600 Ohm)
JU10**	Not connected Connected	For 24 V AC/DC external supply For 12 V DC external supply
JU11	C-A C-B*	J1-9 is external PTT disable J1-9 is external CM out.

* Factory default

** Set at factory according to the specific option. If the WLI module is connected to an MRU Encoder or a DMC-1 JU10 is connected, otherwise it is not connected.

3.2 FUNCTIONAL DESCRIPTION

The default jumper configuration in the WLI covers most applications. However, in the applications described below, changing the following jumpers is necessary:

a. Using the dc level output:

Connected	Not Connected
JU1B	JU3C
JU1C	JU4C
JU3B	JU7C to A
JU4D	
JU7C to B	

b. Using an ac adapter to operate the module directly from ac power (WLI with Radio Only), or from 24 V external dc supply:

JU10 - Not Connected

c. To determine CM busy-high:

CM Input

JU2C to A Not connected
JU2C to B Connected

CM Output

JU6C to A Not connected
JU6C to B Connected

d. To determine low impedance (600 ohm) during reception from the line. (This is recommended when only two WLI modules are connected to the line.)

JU9-Connected.

e. To control PTT to the radio from the user connector, disable PTT to the radio by connecting J1-9 to ground (J1-8).

JU11C to A Connected
JU11C to B not connected.

4. TRIMMERS

4.1 GENERAL

Three trimmers are included in the WLI module. They affect the dBm output to the line (R1), the tone detector and AGC sensitivity (R13) and the tone detector noise threshold (R19). (Refer to the Maintenance section of this manual for adjustment procedure.)

The default adjustment (at factory) of the trimmers is as follows:

R1 - 0 dBm to the line

R13 - -35 dBm sensitivity when receiving from the line.

R19 - 9 V noise threshold.

4.2 FUNCTIONAL DESCRIPTION

Tuning the trimmers is necessary for optimum operation, in the following conditions:

a. Very large distances, or poor line quality. For optimum operation, increase the dBm to the line via R1 (up to 6 dBm) or increase the tone detector and AGC sensitivity via R13 (up to -35 dbm) or both.

b. Strong noise on the line (at the received signal range). For optimum operation, increase noise threshold via R19 (up to 9.5 V) or decrease tone detector and AGC sensitivity, or both.

c. Sensitivity of the CM output to normal voice. For optimum operation, decrease noise threshold via R19 (up to 7.5 V). Watch the LED while performing adjustments - it lights during detector activation .

5. MOUNTING

The WLI module is supplied either as an MRU option (V226 or V307) or as an INTRAC 2000 central station option (V226).

5.1 MRU OPTIONS (V226 or V307)

When the WLI module is supplied as an MRU option, it is mounted as the first module (from the left). In case of MRU with radio and wireline, the WLI module is mounted next to the radio.

5.2 CENTRAL STATION

When the WLI module is supplied as an option of an INTRAC 2000 central station, it is provided with a wall mount kit. If the WLI is an option of a CIU based central station, the proper transformer is also provided (see Figure 1. Housing Detail).

6. EXTERNAL CONNECTIONS

6.1 GENERAL

All electrical cables should be consistent with the mounting location environment and should conform to applicable electrical codes. Use weatherproof cable entrance hardware and proper external housing for outdoor installations. For approved fire and security installations, refer to applicable regulations such as NFPA72D or other local requirements.

6.2 POWER SOURCE

6.2.1 Internal Power Source

The WLI is provided with 12 V dc from the Encoder (via the bus) when an Encoder module is configured in the system.

NOTE

An external connection is required between J1-2 (VBat) on the Encoder user connector and J1-13 on the WLI user connector to supply the charging current for the battery.

6.2.2 External Power Source

When an Encoder module is not configured in the system (option V236 or V307), an external power source must be connected to the WLI module user connector J1. Refer to Table 2. External Power Source Connections.

For ac power source, the transformer kits FLN5879 (115 V ac) or FLN5880 (230 V ac) are available.

Table 2. External Power Source Connections

Source	JU10	External Connection
12 V dc	Connected	+ = J1-13 - = J1-8
24 V dc	Not Connected	+ = J1-13 - = J1-8 short wire between J1-14 and J1-8 (for surge protection)
24 V ac	Not Connected	J1-13 and J1-14
115 V ac	Not Connected	As for 24 V ac thru FLN5879 115 V ac transformer kit
230 V ac	Not Connected	As for 24 V ac thru FLN5880 230 V ac transformer kit

NOTE

JU10 is set at factory according to the specific option. If the WLI module is connected to an MRU Encoder or a DMC-1, JU10 is connected, otherwise it is not connected.

In MRU less Encoder (Decoder only) configuration, the power source is connected to the WLI only and not to the Decoder module.

6.3 LINE

Connect the line to J1-1 and J1-3 on the user connector (2-wire only). The polarity is not important even for the dc level output option.

NOTE

When a radio is also included in the configuration, locate the wires as far as possible from the radio antenna.

6.4 PROTECTIVE GROUND

J1-2 of the user connector is the protective ground for the module and must be connected directly to a separate electrical ground, preferably a buried water pipe or any other direct earth ground.

6.5 EXTERNAL RADIO CONNECTION

Connections to an external radio are made through the user connector. Do not use wires longer than 3 feet (914 mm) for the connections, and use RF shielded cable.

Table 3. External Radio Connections

WLI Function	User Conn. Pin	Connection
GND	J1-8	To radio GND
Ext PTT out*	J1-11	To radio PTT input (active low)
Ext CM in	J1-5	To radio CM output (busy low by default)
FSK TX	J1-12	To transmitter input
FSK RX	J1-10	To receiver output.

* The PTT dry contact output may be used through terminals J1-6 and J1-7.

In cases where the radio receiver output is not 100 mV rms, it is necessary to adjust the FSK output of the Encoder according to the level of the radio receiver output. Refer to the Maintenance section of this manual for adjustment procedures.

NOTE

The FSK TX output signal to the radio transmitter has high output impedance (20k ohm). In cases where the external radio has low input impedance, it may be necessary to replace C12 on the WLI with 0.15 uF capacitor.

6.6 CENTRAL STATIONS

Connections to a central station are made through the user connector. Do not use wires longer than 3 feet (914 mm) and use shielded cable.

Table 4. Central Station Connections

WLI Function	User Conn. Pin	Central Connection
GND	J1-8	To GND
Ext PTT in	J1-4	To PTT output
Ext CM out	J1-9*	To CM input (active low by default)
FSK TX	J1-12	To FSK RX
FSK RX	J1-10	To FSK TX
AC/DC Plus	J1-13**	
AC Plus	J1-14**	

* Default connected JU11C to B.

** If connected to DMC-1, the supply to the WLI may be 12 V dc directly from the DMC. If connected to CIU, use an ac adapter. Refer to Table 2. External Power Source Connections.

In order to set the FSK output signals of the central station at the same level as the radio received signal (if a radio is included in the system), the FSK output of the central station has to be adjusted to 100 mV rms (instead of 700 mV rms). Refer to the Maintenance section of this manual for adjustment procedures.

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THEORY OF OPERATION

1. GENERAL

The WLI module provides the interface between FSK signals transmitted by the MRU, 2-wire lines and radio.

The WLI module provides the following functions:

- Amplification of FSK signals.
- Impedance matching.
- Surge protection.
- Control of the MRU, radio and wireline using CM and PTT signals.

2. BLOCK DIAGRAM DESCRIPTION
(Refer to Figure 1. WLI Module Block Diagram)

The connections to the WLI are implemented via three connectors:

a. Bus connector - to the MRU bus

b. Radio connector - to the MRU radio

c. User connector - to the wireline, power supply, external radio and INTRAC 2000 central stations.

FSK signals that are amplified and transferred by the WLI **to** the line, may come from two sources (one at a time):

- MRU Encoder - FSK transmitted signals.
- Radio receiver - FSK received signals.

The signals that are transferred **to** the line are also passed on to the AGC circuit and appear at the Decoder input and radio transmitter simultaneously. They perform according to their source:

* When the MRU Encoder transmits - the Decoder ignores the signals which are passed on to the radio transmitter together with the PTT control signal.

* When the radio receives - the radio transmitter is blocked and the signals are passed on to the Decoder together with the CM signal.

FSK signals **from** the line are received by the AGC of the WLI and passed on to the Decoder and radio transmitter simultaneously. The tone detector detects FSK tones on the line and provides the CM signal to the MRU and the PTT signal to the radio.

An analog switch blocks the amplifier to the line while receiving from the line.

The logic circuit uses PTT, CM and Tone Detector as input signals. It provides the control signals for the analog switch and the tone detector, in order to block them while transmitting FSK signals on the line.

For the dc level output (jumper selectable), the dc line driver provides the dc to the line. As a result of the

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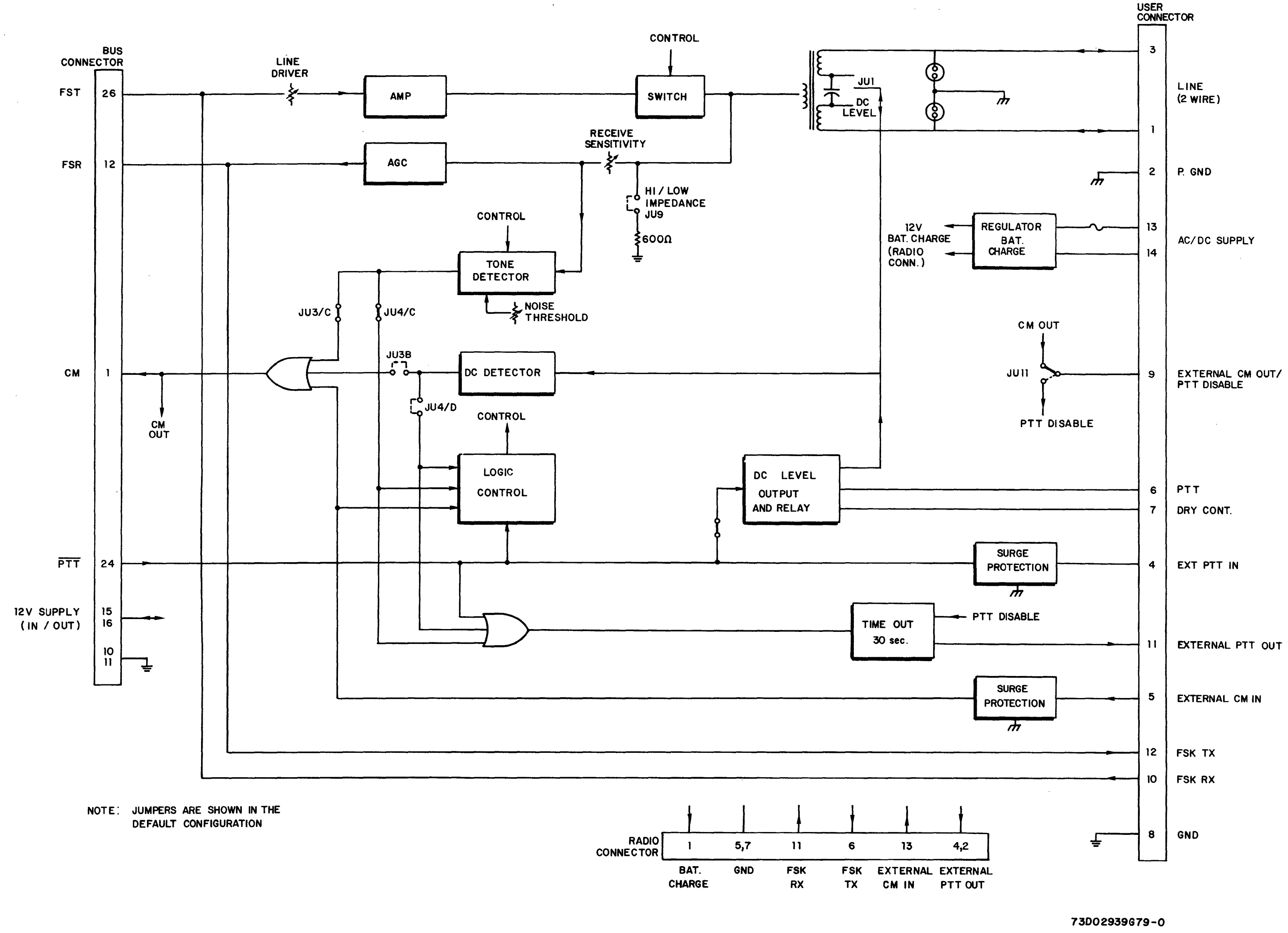


Figure 1. WLI Module Block Diagram

above, the dc detector on the other side of the line initiates CM and PTT signals.

Whenever the WLI module is configured as "radio only" MRU, its regulator and battery charger may be used to operate the WLI from external dc or ac supply.

3. DETAILED DESCRIPTION

3.1 LINE DRIVER

Operational amplifiers U1B and U1A with resistors R1-R5 amplify FSK signals to the line if the control signal for the analog switches (U7) is E=0 and F=1. Capacitors C1, C2 and C8 provide dc blocking. Capacitors C3 with C6 act as low pass filter. Resistor R4 in series with the analog switch ON resistance and the winding resistance of T1 reflect 600 ohm impedance to the line. Resistor R1 is used to adjust the output level to the line to the desired value.

3.2 BUFFER

U8A buffers the AGC circuit from the line transformer to enable a reflection of high impedance to the line during reception from the line. It is needed whenever large numbers of MRUs with WLI modules are connected to the same line. Otherwise, when only two MRUs with WLI modules are connected to the line, jumper JU9 may be connected to reflect 600 ohm.

3.3 AGC

The AGC consists of amplifier, precise rectifier and dynamic voltage divider. U8D with resistors R11-R13 is the amplifier. U8C with diodes CR1, CR2 is the precise rectifier at the amplifier feedback. It samples the amplifier output and controls the dynamic resistance of the MOSFET Q9, according to the amplifier output. The voltage divider at the amplifier input consists of resistors R11, R12 and the dynamic resistance of Q9. It controls the amplification of the amplifier according to the feedback. Capacitor C14 provides dc blocking. Resistors R7-R9 and capacitor C16 set a critical damping for the dynamic response of the AGC. Resistor R13 may be used to reduce the sensitivity of the AGC but also affects the sensitivity of the tone detector.

3.4 TONE DETECTOR

The tone detector consists of:

- buffer
- filter
- absolute value circuit
- comparator.

U8B and resistors R33, R34 with capacitors C27 and C30 comprise the buffer against RF interference at critical points on the printed circuit board. Potentiometer R13 is used to adjust both the sensitivity of the tone detector and the AGC.

U9A and U9B comprise the filter with maximum amplification on two frequencies, 900 and 1500 Hz. U9C with diodes CR3 and CR4 comprise the rectifier. U9D with capacitor C23 and resistor R22 comprise a summing circuit and integrator to filter the rectified signal to positive dc voltage, the response time is about 10 ms.

U1D is the comparator with 0.5 V hysteresis, fixed by resistors R17, R21. The reference voltage is applied by resistors R18-R20. It is stabilized by zener diode VR4 and filtered by capacitor C22. Resistor R19 is used to change the reference voltage between 7.5 V and 9.5 V. This is needed to set those decision points that identify valid signs which activate the tone detector. The control signal at point E is used to disable the tone detector during transmission to the line. Capacitor C7 provides delay of transition from disable state to active state of the tone detector.

The tone detector output is connected to the LED by jumper JU7 to indicate tone detector activation.

3.5 REGULATOR AND BATTERY CHARGER

The regulator and battery charger circuit consists of:

- protection circuit
- rectifier
- regulator
- charger
- current limit circuit.

The protection on the external supply is against transients (VZ2 varistor) and against overloading (fuse F1, 2A). Diode bridge CR11-CR14 and capacitor C35 is the rectifier feeding the 19 V regulator Q6, VR6. The charger is temperature dependent, current source consists of Q7, RT1 and supplies about 55 mA at temperatures above 0°C and down to about 15 mA at -30°C. It complies with the specifications of the battery and the radio current consumption. Q8 limits the maximum current consumed by the module.

3.6 DC LINE DRIVER AND DC DETECTOR

The dc is connected to the 2-wire line through two windings of transformer T1 in opposite direction of the current flow, and with varistor VZ1 to protect against transients. The 2 W resistors R51 and R52 protect the dc supply from driving dc to a shorted circuit line. The relay K1 provides connection between the line and the dc detector (when monitoring dc on the line) or the VD supply voltage (when driving dc to the line). Q2 is the switching transistor for the relay, as a function of PTT input to the module.

The dc detector consists of current limit resistors R48 and R49, diode bridge CR16-CR20 and an opto-coupler U2 for dc isolation between the line and the WLI module. It may be connected by jumper JU7 for LED indication.

3.7 CM OUTPUT

U4D and U4A is a triple OR gate, to select the activation of the CM output as a function of tone detector, dc detector or external CM input. Q5 is the switching transistor and U3C is used to change the polarity of the CM signal.

3.8 PTT OUTPUT

U4B, diodes CR15 and CR16 is a triple OR gate to select the activation of the PTT output as a function of tone detector, dc detector or external PTT input. Q4 is the switching transistor for the PTT output. Capacitors C41, C42, diode CR21 and resistor R50 comprise an analog timeout delay to eliminate PTT signals longer than 30 seconds, which cause series disfunctions (continuous transmission which prevents other MRUs from transmitting). Another alternative is to use the PTT output as a dry contact from a relay instead of as a switching transistor. In such a case, the PTT output is a function of external PTT input signal (or MRU PTT).

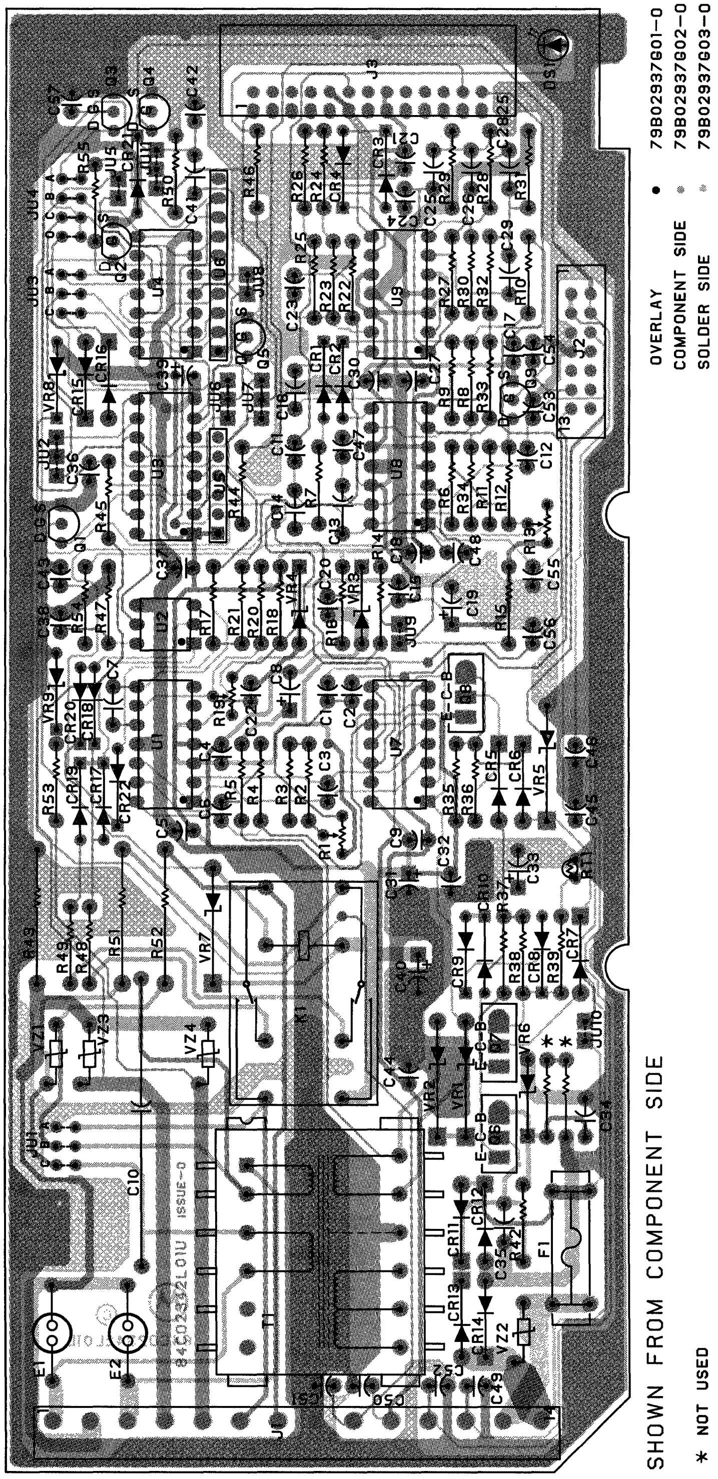
3.9 CONTROL

The control circuit provides the control signals that switch the WLI module between reception and transmission with the necessary delays for transitions. The inputs for the control circuit are PTT, CM, tone detector and dc detector. The outputs are the complementary pair of signals E and F that control the analog switch U7 of the line driver, and disable the tone detector during transmission to the line.

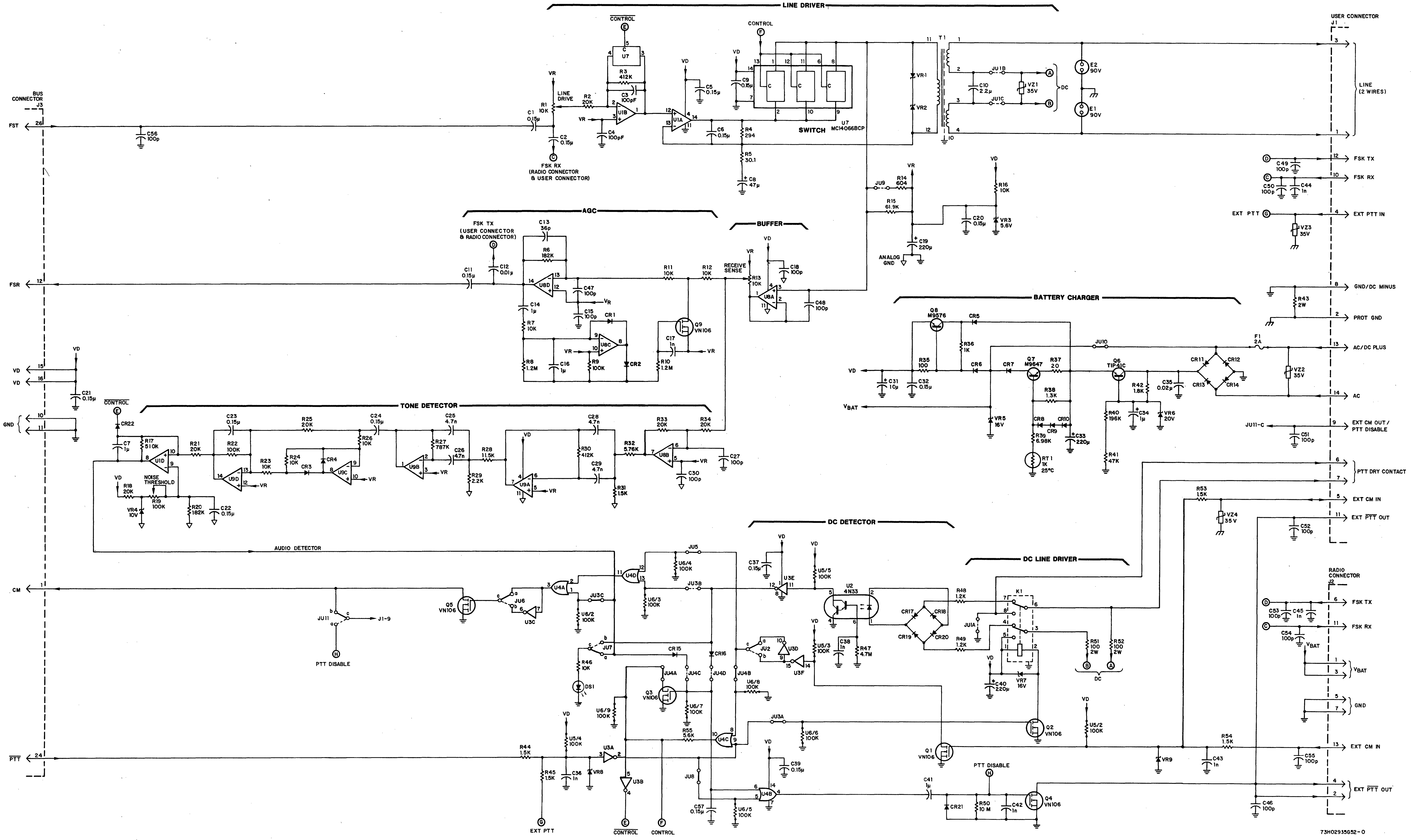
U3A is the PTT input circuit with resistors R44, R45 and zener VR8 and varistor VZ3 as the surge protection. Q1 and U3F is the CM input circuit with resistors R53, R54 and VR9, VZ4 as the surge protection. U3D and jumper JU2 provide selection of polarity - busy high or low.

U4C is an OR gate which produces the control signals that enable transmission to the line as a function of PTT or CM input signal.

Q3 and resistor R55 are used to deactivate the control signals during reception from the line, as a function of the tone or dc detectors. Capacitor C57 and U6/7 provide the necessary delay for the transition.


OVERLAY ● 79B02937G01-0
COMPONENT SIDE 79B02937G02-0
SOLDER SIDE 79B02937G03-0
SHOWN FROM COMPONENT SIDE
* NOT USED
84C02342L01U ISSUE-0

FLN1467A Wireline Interface
Printed Circuit Board
September, 1986



FLN1467A Wireline Interface
Schematic Diagram
September, 1986

parts lists

FLN4422A Wireline Interface Board

PL-0385-O

Reference Symbol	Motorola Part No.	Description
		Capacitor fixed: uF ±1% unless otherwise stated
C1, C2	21-84008H03	0.15, 50 V
C3, C4	21-05455G01	100 pF, 50 V
C5, C6	21-84008H03	0.15, 50 V
C7	21-08029H07	1, ±10%, 50 V
C8	23-84538G06	47, ±20%, 20 V
C9	21-84008H03	0.15, 50 V
C10	08-02083C45	2.2, 250 V
C11	21-84008H03	0.15, 50 V
C12	21-84008H24	0.01, ±20%, 25 V
C13	21-84494B43	36 pF, 500 V
C14	21-08029H07	1, ±10%, 50 V
C15	21-05455G01	100 pF, 50 V
C16	21-08029H07	1, ±10%, 50 V
C17	21-02384C12	1 nF, 100 V
C18	21-05455G01	100 pF, 50 V
C19	23-08524G02	220, 35 V
C20 thru 24	21-84008H03	0.15, 50 V
C25, C26	21-02384C07	4.7 nF, 100 V
C27	21-05455G01	100 pF, 50 V
C28, C29	21-02384C07	4.7 nF, 100 V
C30	21-05455G01	100 pF, 50 V
C31	23-84665F01	10, -10+100, 25 V
C32	21-84008H03	0.15, 50 V
C33	23-08524G02	220, 35 V
C34	21-08029H07	1, ±10%, 50 V
C35	21-82428B26	0.02, +80-20, 5 V
C36	21-02384C12	1 nF, 100 V
C37	21-84008H03	0.15, 50 V
C38	21-02384C12	1 nF, 100 V
C39	21-84008H03	0.15, 50 V
C40	23-08524G02	220, 35 V
C41	21-08029H07	1, ±10%, 50 V
C42 thru 45	21-02384C12	1 nF, 100 V
C46 thru 56	21-05455G01	100 pF, 50 V
C57	21-84008H03	0.15, 50 V
		Diode
CR1 thru 4	48-83654H01	A/I
CR5 thru 7	48-82466H13	Silicon Rect., 200 V
CR8 thru 10	48-11034A01	
CR11, CR12	48-82466H13	200 V
CR13, CR14	48-82466H13	200 V
CR15 thru 17	48-83654H01	A/I
CR18 thru 22	48-11034A01	
		LED
DS1	48-80159E11	Green LED
		Spark Gap
E1, E2	80-83029H03	SG
		Fuse
F1	65-02069C18	2A, 250 V
		Connector
J1	28-02414H03	user connector
J2	28-08044H01	14-pin header boxed
J3	28-08044H06	26-pin header plug
		Relay
K1	80-02576K02	2 Form C
		Transistor
Q1 thru 5	48-08237G05	VNO106
Q6	48-02089C14	TIP41C
Q7	48-00869647	M9647
Q8	48-00869576	M9576
Q9	48-08237G05	VNO106
		Resistor, fixed:±1%, 1/4 W unless otherwise stated
R1	18-02467C01	10 k pot. ±10%
R2	06-02478C84	20 k
R3	06-10621E48	412 k
R4	06-02477C13	294 ohm
R5	06-02170C19	30.1 ohm
R6	06-02479C69	182 k, 1/10 W
R7	06-02478C55	10 k
R8	06-00124B24	1.2 M, ±5%
R9	06-02170C12	100 k
R10	06-00124B24	1.2 M, ±5%
R11, R12	06-02478C55	10 k
R13	18-02467C01	10 k, pot. ±10%
R14	06-02477C41	604 ohm
R15	06-02479C29	61.9 k
R16	06-02478C55	10 k
R17	06-11009D15	510 k, ±5%
R18	06-02478C84	20 k
R19	18-02467C36	100 k, pot. ±10%, 0.5W
R20	06-02479C69	182 k, 1/10W
R21	06-02478C84	20 k
R22	06-02170C12	100 k
R23, R24	06-02478C55	10 k
R25	06-02478C84	20 k
R26	06-02478C55	10 k
R27	06-10621E75	787 k
R28	06-10621C97	11.5 k
R29	06-02477C92	2.21 k
R30	06-10621E48	412 k
R31	06-02477C77	1.5 k
R32	06-10621C68	5.76 k
R33, R34	06-02478C84	20 k
R35	06-02170C67	100 ohm, 1/10W
R36	06-00124C49	1 k, ±10%
R37	06-10621A30	20 ohm, ±1%
R38	06-10621C06	1.3 k, ±1%
R39	06-10621C76	6.98 k, ±1%
R40, R41	-----	not used
R42	06-11009C55	1.8 k, ±5%
R43	17-91510010	100 ohm, ±5% 2 W
R44, R45	06-02477C77	1.5 k
R46	06-02478C55	10 k
R47	06-00124B38	4.7 M, ±5%
R48, R49	06-11009E51	1.2 k, ±5%
R50	06-00124B46	10 M, ±5%
R51, R52	17-91510010	100 ohm, ±5%, 2 W
R53, R54	06-02477C77	1.5 k
R55	06-11009C67	5.6 k, ±5%
		Thermistor
RT1	06-83600K02	1 k, 25°C
		Transformer
T1	25-83036L01	
		Integrated Circuit
U1	51-83629M18	LM224
U2	51-02169C02	4N33
U3	51-82884L02	4049
U4	51-02073C37	4071
U5	51-02599K10	CIP
U6	51-02599K01	CIP
U7	51-02581K04	4066
U8, U9	51-83629M18	LM224
		Zener Diode
VR1, VR2	48-02064C18	12 V
VR3	48-02064C36	5.6 V
VR4	48-82256C11	10 V
VR5	48-02064C77	16 V
VR6	48-02064C95	20 V
VR7	48-02064C77	16 V
VR8, VR9	48-02064C78	14 V
		Varistor
VZ1 thru VZ4	06-02597K06	MOV, 45 V
	Non-Referenced Items	
	42-02226C04	clips for fuse
	28-02218K12	2-pin plug
	29-02219K01	terminal jumper
	84-02342L01	PC Board

Note: For optimum performance, diodes and integrated circuits **must** be ordered by Motorola part numbers.

FLN5720A Hardware Kit

PL-0395-O

Reference Symbol	Motorola Part No.	Description
	Non-Referenced Items	
	01-02717G06	Terminal and wire assembly includes:
	29-02231C07	Lug, terminal; 2 used
	03-00129675	Screw, lock, 4-40 x 1/4"; 2 used
	03-00134309	Screw, lock, 4-40 x 3/16"
	31-08509G04	Terminal with socket
	54-08125H01	Label, connector

FLN4504A Label Kit

PL-0396-O

Reference Symbol	Motorola Part No.	Description
	Non-Referenced Items	
	54-02443L01	Label
	54-08124H09	WLI label
	54-08635G16	WLI label

FLN4347A Housing

PL-0380-O

Reference Symbol	Motorola Part No.	Description
	02-02427C01	Lock nut 4X40, 1 used
	03-08026H05	Cap scr 8X32 7/8", 2 used
	03-82210E15	Captive screw, 2 used
	15-08513H01	Housing bottom, 1 used
	15-08586G01	Housing cover, 1 used
	15-08587G01	Door box, 1 used
	22-02482C02	Dowel pin, 1 used

MAINTENANCE

1. GENERAL

No routine maintenance is required for the WLI module, however due to changes and improvements, (such as noise and line quality) adjustment of the module may be required. Therefore, this section describes only the adjustment procedure for noise and line quality.

Refer to the Installation section in this manual for the various options, connections and jumper configurations.

The default adjustments by factory are:

- 0 dBm to the line
- -35 dBm sensitivity for tone detector
- -35 dBm sensitivity for AGC
- 9 V noise threshold for tone detector

In order to access trimmers, the module must be disassembled, refer to the Installation section for disassembly instructions.

2. FSK OUTPUT LEVEL ALIGNMENT

The intensity of the signal delivered to the line depends upon the rate of input signal and the amplification of the line driver amplifier adjusted by resistor R1. The input signal to the line driver amplifier is not only the MRU/central station signal, but also the radio receiver received signal, which is 65-95 mV rms (MRU radio). Therefore, the MRU/central station output signal must be in correlation with the receiver output signal. The rate of input signal is 100 mV rms (default) if connected to the MRU. If connected to the CIU, adjust the output level of the CIU to 100 mV rms via R76, (instead of the default value 700 mV rms). Refer to 68P02913G20 CIU Instruction Manual, Maintenance section 8.1 for further details.

For adjustment of the DMC-1, refer to 68P02936G10 DMC-1 instruction manual.

In order to adjust R1 make the following connections:

a. Connect the WLI module to a power supply.

b. J1-4 to J1-8 (PTT activation)

c. 600 ohm (5%) resistor between J1-1 and J1-3 (line input)

d. Signal generator 900 Hz 100 mV rms to J1-10 and J1-8.

e. Voltmeter between J1-1 and J1-3.

Adjust R1 to read the voltage according to the desired dBm (usually between -10 and +5 dBm).

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The following formulas may be used:

$$dBm = 10 \times \log \left[\frac{V^2 rms \times 10}{6}\right]$$

$$Vrms = \sqrt{\frac{6}{10} \times 10^{\left(\frac{dBm}{10}\right)}}$$

If an external radio is used, it is necessary to adjust the FSK output of the Encoder module according to the level of the radio receiver output, and adjust R1 in the WLI module according to the steps above. Assure that in Step d. the signal generator output is identical to the radio receiver output.

3. NOISE THRESHOLD

Connect a voltmeter to U1-9 and adjust R19 to read the desired threshold. For maximum sensitivity (minimum noise immunity), the threshold may be adjusted to 7.5 V. For maximum noise immunity (minimum sensitivity), the threshold should be 9.5 V. Do not exceed the extreme values above.

4. TONE DETECTOR AND AGC SENSITIVITY

Tone detecting and AGC sensitivity should be performed after adjusting the noise threshold. Refer to the previous paragraph.

Adjust R13 to minimum (full rotation counter clockwise). Connect a signal generator with 600 ohm output impedance between J1-1 and J1-3 (line).

Set the signal generator to 900 Hz with the desired sensitivity (see the formulas above, voltage and dBm). Adjust R13 clockwise until DS1 (green LED) indicates tone detector activation.

Consequently the AGC is adjusted.

INTRAC 2000
Modular Remote Unit
Wireline Interface

68P02938G05-O

MOTOROLA INC.
Communications
Sector

AMRU WIRELINE

Model FRN1690A

Notice to Customer

The FRN1690A AMRU Wireline Module is a modification of the original FLN1467A MRU Wireline Interface Module.

The 68P02938G05 Instruction Manual provided is still applicable except for the changes described below.

In order to enable the use of an AMRU system with Wireline the following procedure is necessary (only if the user wants to adapt a MRU WLI module already in his possesion):

Step 1. In the WLI PC board (FLN4422A) replace C12 from 0.01uF to 0.15uF, p/n 2184008H03 (conversion kit FLN4655A).

Step 2. Mark the PC board FLN4422A-1.

KIT BREAKDOWN

FRN1690A AMRU Wireline Interface

FLN4422A	WLI Main Board
FLN5720A	Hardware
FLN4347A	Modular Housing
FLN4655A	Conversion Kit
FLN4656A	Label Kit
68P02945G51	AMRU Wireline instructions section

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technical writing services
1301 E. Algonquin Road, Schaumburg, Il. 60196

parts list

FLN4655A Conversion Kit PL-0497-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	21-84008H03	Capacitor 0.15

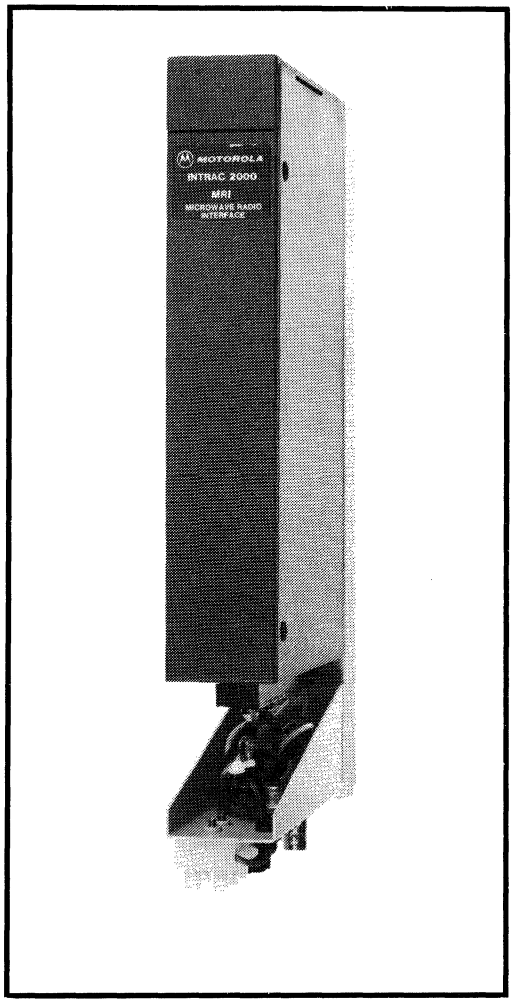
FLN4656A AMRU WLI Label Kit PL-0498-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	54-08635G20	AMRU WLI label
	29-08551C01	Label
	42-02415C01	WLI label

MOTOROLA

INTRAC 2000®

Modular Remote Terminal Unit
Microwave Radio Interface



Instruction Manual

68P02963G50-O

COMMERCIAL WARRANTY
(STANDARD)

Motorola radio communications products are warranted to be free from defects in material and workmanship for a period of ONE (1) YEAR, (except for crystals and channel elements which are warranted for a period of ten (10) years) from the date of shipment. Parts, including crystals and channel elements, will be replaced free of charge for the full warranty period but the labor to replace defective parts will only be provided for One Hundred-Twenty (120) days from the date of shipment. Thereafter purchaser must pay for the labor involved in repairing the product or replacing the parts at the prevailing rates together with any transportation charges to or from the place where warranty service is provided. This express warranty is extended by Motorola Communications and Electronics, Inc., 1301 E. Algonquin Road, Schaumburg, Illinois 60196, to the original purchaser only, and only to those purchasing for purpose of leasing or solely for commercial, industrial, or governmental use.

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In the event of a defect, malfunction or failure to conform to specifications established by seller, or if appropriate, to specifications accepted by Seller in writing, during the period shown, Motorola, at its option, will either repair or replace the product or refund the purchase price thereof, and such action on the part of Motorola shall be the full extent of Motorola's liability hereunder.

This warranty is void if:

a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage;
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

This warranty extends only to individual products, batteries are excluded, but carry their own separate limited warranty. Because each radio system is unique, Motorola disclaims liability for range, coverage, or operation of the system as a whole under this warranty except by a separate written agreement signed by an officer of Motorola.

Non-Motorola manufactured products are excluded from this warranty, but subject to the warranty provided by their manufacturers, a copy of which will be supplied to you on specific written request.

In order to obtain performance of this warranty, purchaser must contact its Motorola salesperson or Motorola at the address first above shown, attention Quality Assurance Department.

This warranty applies only within the United States.

EPS-27734-O

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EPS-34440-B

MOTOROLA INC.
Communications
Sector

INTRAC 2000®
Modular Remote Terminal Unit
Microwave Radio Interface

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FOREWORD

1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar types of equipment. It contains all service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date are incorporated by Instruction Manual Revisions (SMR). These SMR's are added to the manuals as the engineering changes are incorporated into the equipment.

2. MODEL AND KIT IDENTIFICATION

Motorola equipments are specifically identified by an overall model number on the nameplate. In most cases, assemblies and kits which make up the equipment also have kit model numbers stamped on them. When a production or engineering change is incorporated, the applicable schematic diagrams are updated.

3. SERVICE

Motorola's National Service Organization offers one of the finest nation-wide installation and maintenance programs available to communication equipment users. This organization includes approximately 900 authorized Motorola Service Stations (MSS) located throughout the United States, each manned by one or more trained, FCC licensed technicians.

These MSS's are independently owned and operated and were selected by Motorola to service its customers. Motorola maintenance is available on either a time and material basis or on a periodic fixed-fee type arrangement.

The administrative staff of this organization consists of national, area and district service managers and district representatives, all of whom are Motorola employees with the objective to improve the service to our customers.

Should you wish to purchase a service contract for your Motorola equipment, contact your Motorola Service Representative, or write to:

National Service Manager
Motorola Communications and Electronics, Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

REPLACEMENT PARTS ORDERING

ORDERING INFORMATION

Motorola maintains a number of parts offices strategically-located throughout the United States. These facilities are staffed to process parts orders, identify part numbers, and otherwise assist in the maintenance and repair of Motorola Communications Sector products.

Orders for all parts *except* crystals, active filters, channel elements, and Vibrasender and Vibrasponder resonant reeds should be sent to the nearest area parts center. Orders for instruction manuals should also be sent to the area parts center.

When ordering replacement parts or equipment information, the complete identification number should be included. This applies to all components, kits, and chassis. If the component part number is not known, the order should include the number of the chassis or kit of which it is a part, and sufficient description of the desired component to identify it.

Orders for crystals, channel elements, active filters, and reeds should be sent to the Component Product Sales & Service address listed below. Crystal and channel element orders should specify the crystal or channel element type number, crystal and carrier frequency, and the chassis model number in which the part is used.

Orders for active filters, Vibrasender and Vibrasponder resonant reeds should specify type number and frequency, should identify the owner/operator of the communications system in which these items are to be used; and should include any serial numbers stamped on the components being replaced.

COMPONENT PRODUCT SALES & SERVICE OFFICE

All Mail Orders
Motorola, Inc.
Component Product Sales & Service
P.O. Box 66191, O'Hare International Airport
Chicago, IL 60666

Correspondence
Motorola, Inc.
Component Product Sales & Service
2553 N. Edgington Street, Franklin Park, IL 60131
Tel: 312-451-1297, TWX: 910-227-0799, Telex: 433-0067

AREA PARTS OFFICES

Western Area Parts
1170 Chess Drive, Foster City, CA 94404
Tel: 415-349-8621, TWX: 910-375-3877

Pacific-Southwestern Area Parts
P.O. Box 85036, San Diego, CA 92138
Street Address:
9980 Carroll Canyon Road, San Diego, CA 92131
Tel: 619-578-8030, TWX: 910-335-1516

Gulf States Area Parts
P.O. Box 73115, 1140 Cypress Station, Houston, TX 77090
Tel: 713-537-3636, TWX: 910-881-6392

Southwestern Area Parts
P.O. Box 34290, 3320 Belt Line Road, Dallas, TX 75234
Tel: 214-620-8511, TWX: 910-860-5505

Midwest Area Parts
1313 E. Algonquin Rd., Schaumburg, IL 60196
Tel: 312-576-7430, TWX: 910-693-0869

Southeastern Area Parts
P.O. Box 368, Decatur, GA 30031
Street Address:
5096 Panola Industrial Blvd., Decatur, GA 30032
Tel: 404-987-2232, TWX: 810-766-0876

Rocky Mountain Area Parts
20 Inverness Place East, Englewood, CO 80122
Tel: 303-790-2323, TWX: 910-935-0785

East Central Area Parts
12955 Snow Road, Parma, OH 44130
Tel: 216-433-1560, TWX: 810-427-9424

Eastern Area Parts
85 Harristown Road, Glen Rock, NJ 07452
Tel: 201-447-4000, TWX: 710-988-5614

Mid-Atlantic Area Parts
7230 Parkway Drive, Hanover, MD 21076
Tel: 301-796-8763, TWX: 710-862-1941

National Accounts
Railroad, Airlines, and Telephone Sales
1313 E. Algonquin Rd., Schaumburg, IL 60196
Tel: 312-576-6512, TWX: 910-693-0869

All Canadian Orders
Motorola, Ltd., National Parts Department
3125 Steeles, Ave. E., Willowdale, Ontario M2H 2H6
Tel: 416-499-1441, TWX: 610-491-1032,
Telex: 06-526258

National Data Services

1171 West 17th Street, Tempe, AZ 85281
Tel: 602-994-6472, TWX: 910-951-1334

All Countries Except U.S. & Canada

Motorola, Inc., International Parts Department
1313 E. Algonquin Rd., Schaumburg, IL 60196. U.S.A.
Tel: 312-576-7241, TWX: 910-693-0869
Telex: 722443, Cable: MOTOL PARTS

PERFORMANCE SPECIFICATIONS

GENERAL

Power Input	-28 V dc min to -18 V dc max.
Current Consumption	80 mA typical @-24 V dc 100 mA max @ -24 V dc
Operating Temperature	-20°C to +55°C.
Relative Humidity	95% at 40°C, without condensation.
Housing	Thermo-plastic module.
Dimensions	1.6" X 8.3" X 3.7" (H x W x D) 40.64 X 210.82 X 93.98mm
Weight	0.9 lb (0.400 Kg)
On Board Display	Red LED - Transmit ON (PTT) Green LED - Receive ON (busy channel) (CM)
Operation	Half duplex

INTERFACE TO MICROWAVE RADIO

Connection to radio baseband	via RG59 coax cable, 2 M length maximum.
2-way radio link	no bridging amplifier required.
3-way radio link	through baseband combiner
FSK tones	5300 Hz/5900 Hz in 4-8 KHz slot 9300 Hz/9900 Hz in 8-12 KHz slot
Transmit level*	-26 dBm to -56 dBm user adjustable (continuous)

* Signal levels are for 75 ohm baseband (37.5 ohm effective load).

Receive level*	-13 dBm to -53 dBm user adjustable (jumper selectable in two 20 dB ranges)
Transmit out of band noise	50 dB below carrier
Transmit output impedance	> 2 k ohm
Receive input impedance	> 2 k ohm
Baseband loading	< 0.15 dB
East - West isolation	> 70 dB

INTERFACE TO INTRAC

Connection to MRTU Basic Module	26-pin flat cable connector
Transmit input level	120 mV rms to 200 mV rms
Transmit input impedance	10 k unbalanced
Receive output level	80 mVrms to 1 Vrms
PTT input	Open collector input from an MRTU module: -24 V = Transmit ON Resistance between PTT and -24 V <900 ohm Open circuit = no transmission Resistance between PTT and -24 V >2k ohm Sources 10 mA to -24 V, when PTT goes low to -24 V.
CM output	Open collector output: -24 V = a received signal exists (channel busy) open circuit = no received signal.

KIT BREAKDOWNS

FLN1477A Microwave Radio Interface Module (MRI)

FRN1552A MRI Assembly
FLN7790A MRI Panel Mounting

FRN1552A MRI Assembly

FLN4347A Modular Housing
FLN5720A Hardware Kit
FLN7706A Microwave Radio Interface (MRI) Board
FLN7776A MRI Label Kit

MOTOROLA INC.
Communications Sector

SAFE HANDLING OF CMOS INTEGRATED CIRCUITS

Many of the integrated circuits used in Motorola equipment are of the CMOS (complementary metal oxide semiconductor) type. Because of their high input impedance, CMOS ICs are vulnerable to damage from static charges. Care must be taken in handling, shipping and servicing them and the assemblies in which they are used.

Even though protection devices are provided in CMOS IC inputs, the protection is effective against overvoltage only in the hundreds of volts range encountered in an operating system, in which circuit elements distribute static charges and load the CMOS devices, reducing the possibility of damage. **However, CMOS devices can be damaged by improper handling of the circuit modules even while they are installed in a system.**

To avoid damaging the devices, observe the following precautions:

1. When servicing a circuit module, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.), because they contribute to static build-up.
2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch pins on the CMOS device and associated board wiring.
3. Before touching a circuit module, particularly after moving within the service area, momentarily touch both hands to a bare-metal, earth-grounded surface to dissipate any static charge which may have accumulated on your body.

NOTE

Wearing a Motorola RSX-4015A Conductive Wrist Strap minimizes static build-up during servicing.

4. Although circuit modules can usually be inserted or removed with power applied to the unit, check the INSTALLATION and MAINTENANCE sections of the manual as well as the module schematic diagram, to ensure that the practice is permissible in each specific instance.
5. Use only a grounded soldering iron.
6. All electrically powered test equipment should be grounded. Attach the test instrument ground lead to the circuit module **before** connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

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7. All low-impedance test equipment (such as pulse generators, etc.) should be connected to CMOS devices after power is applied to the CMOS circuitry. Similarly, such low impedance equipment should be disconnected before power is turned off.

8. If a circuit module is removed from the system, place it on a conductive surface such as aluminum foil, grounded through a resistance of approximately 100k ohms.

WARNING

If the aluminum foil is connected directly to ground, beware of possible electric shock from touching the foil while also touching other electrical circuits.

9. When replacing a CMOS device, leave it in its metal rail container or conductive foam until you are ready to insert it into the printed circuit module.

10. Replacement modules shipped from the factory are packaged in a conductive material. Any modules being transported from one area to another should be wrapped in a similar material; aluminum foil may be used. **Never use nonconductive material** for packaging these modules.

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INSTALLATION

1. PRELIMINARY

Carefully inspect the Microwave Radio Interface (MRI) module immediately upon receipt and notify the shipper of any damage that has occurred in transit. The installation procedure consists of mounting the housing and making the necessary external and internal electrical connections.

2. DISASSEMBLY

Follow the directions below for proper disassembly and removal of the MRI module from the chassis.

2.1 MODULE REMOVAL FROM CHASSIS

Step 1. Disconnect power and baseband cables from MRI.

Step 2. Disconnect user connector.

Step 3. Loosen the screw fastening the MRI module to the chassis (refer to Figure 1. MRI Module). Lift and remove the module with its mounting.

Step 4. Lift the latch door at the top of the module and loosen the two captive screws (one at the top and one at the bottom of the module) that attach the module to its mounting and remove the module.

2.2 MODULE DISASSEMBLY

Step 1. Loosen the two screws on the right panel of the MRI housing.

Step 2. Lift the latch door located at the top of the housing.

Step 3. Gently separate the two sides. The printed circuit board is now exposed.

3. JUMPERS

The MRI jumpers are shorted or opened on the user connector. Refer to MRI Jumpers Table below.

The baseband transmit (Tx) level may be adjusted via two potentiometers located behind the module's latch door on the front of the printed circuit board.

The trimmers are factory set for the band pass filters.

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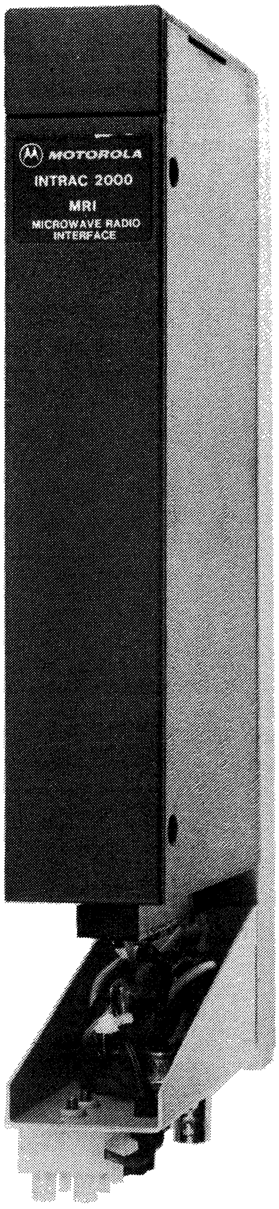
MRI Jumpers Table

Jumper	Position*	Description
JU1	10-11 out**	4-8 kHz baseband range
	10-11 in	8-12 kHz baseband range
JU2	9-10 out**	2-way operation (out 1/in 1 = TX/RX out 2/in 2 = TX/RX)
	9-10 in	3-way operation (out 1/in 1 = TX out 2/in 2 = RX)
JU3	5-8 out**	In 1 high input (-13 dBm to -33 dBm)
	5-8 in	In 1 low input (-33 dBm to -53 dBm)
JU4	5-6 out**	In 2 high input (-13 dBm to -33 dBm)
	5-6 in	In 2 low input (-33 dBm to -53 dBm)

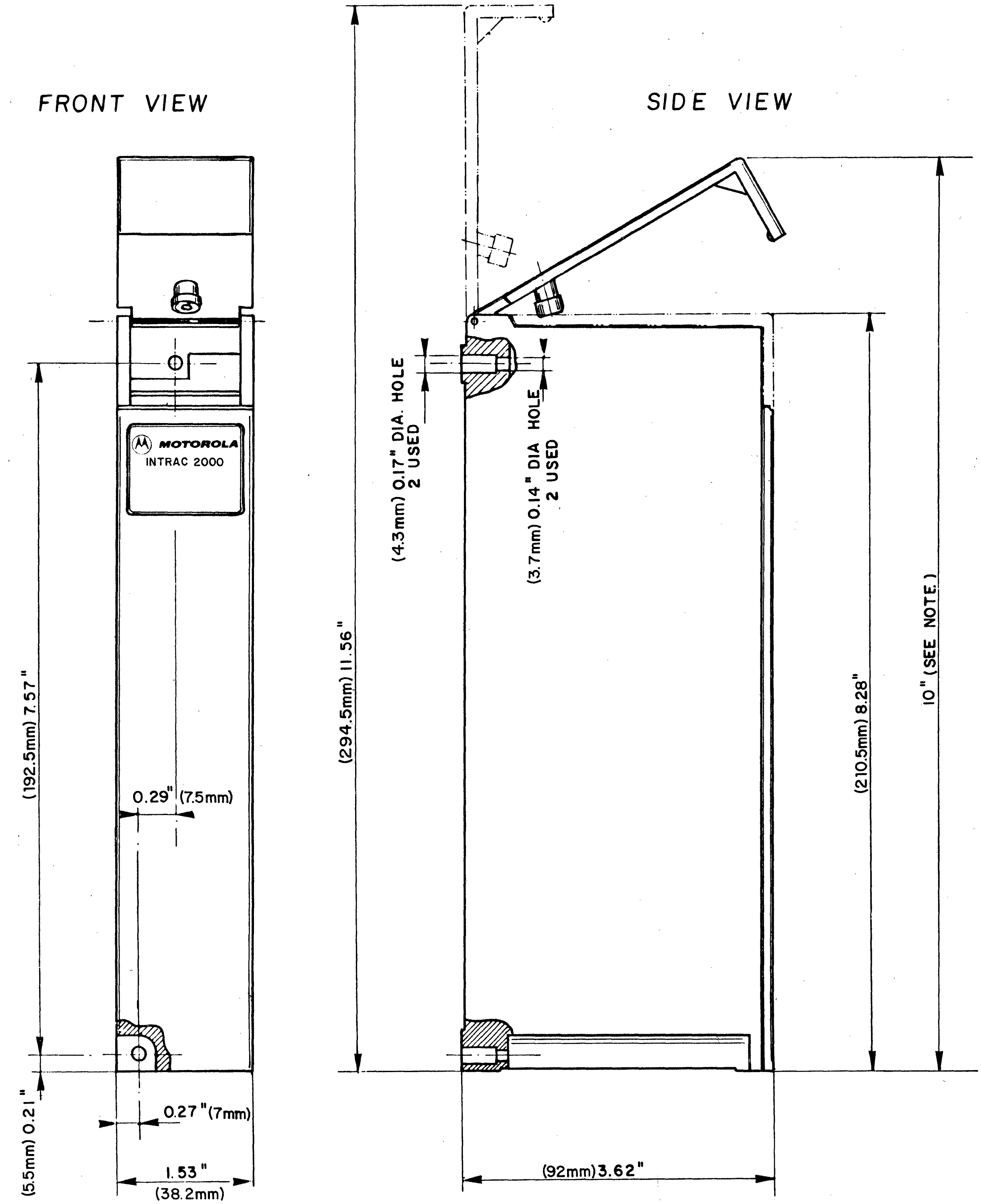
* MRI jumper positions are shorted or opened on the user connector between the above-specified pins. Out = open, in = short.

** Default Setting



69A02941G21-0

Figure 1. MRI Module



NOTE

MINIMUM OPENING FOR REMOVING WIRE CONNECTOR.

73C02936G40-0

Figure 2. Housing Detail

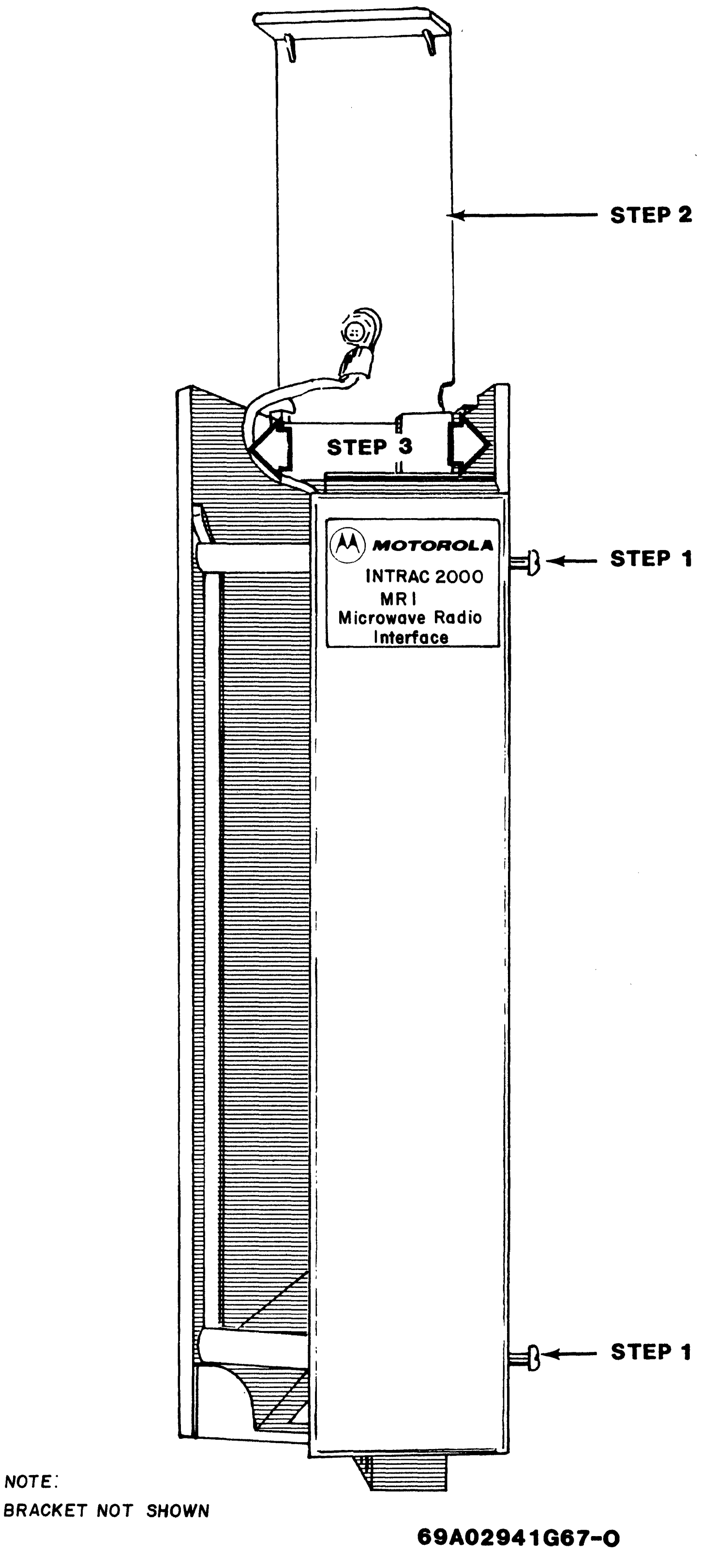


Figure 3. Disassembly

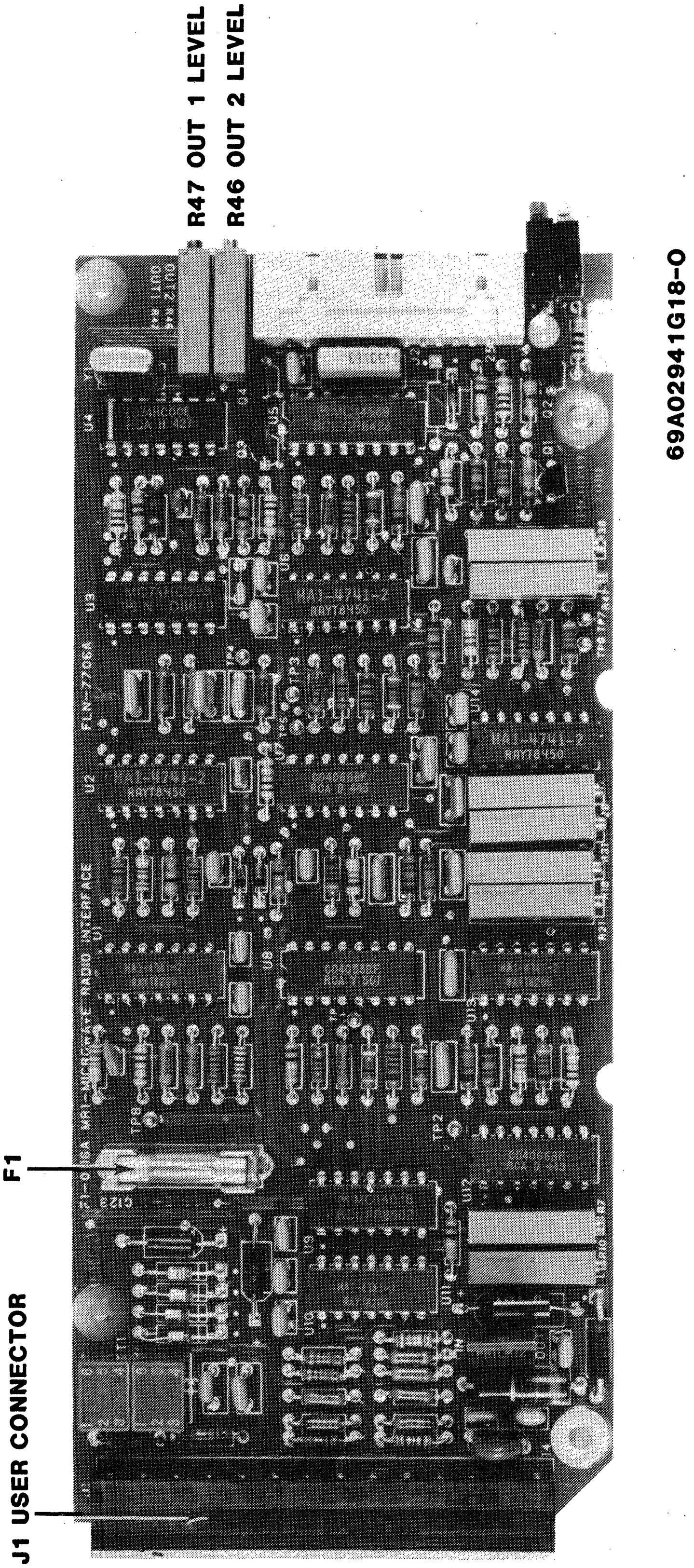


Figure 4. MRI Printed Circuit Board

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THEORY OF OPERATION

1. GENERAL

The Microwave Radio Interface (MRI) enables the INTRAC 2000 MRTU modules to transmit and receive over Motorola STARPOINT microwave radios (2/6 GHz), or similar radios, using either a 4-8 kHz or 8-12 kHz frequency slot.

The MRI is connected between the MRTU Basic Module and the radio transmitter and receiver. The MRI is physically connected to the MRTU Basic Module via the bus (through the flat cable connector) and to the radio via coax cables (through the user connector). Refer to Figure 1. Interconnection Diagram.

In the transmit mode, the FSK tones (900/1500 Hz) generated by the MRTU Basic Module are received through the bus and up-mixed. After mixing, the undesired frequencies are filtered out and the tones are translated up to the 4-8 kHz slot or to the 8-12 kHz slot (user selectable). The output levels are adjustable within a 30 dB range and are sent out to the radio's transmitter through baseband transformers, providing a floating output/input to or from the radio.

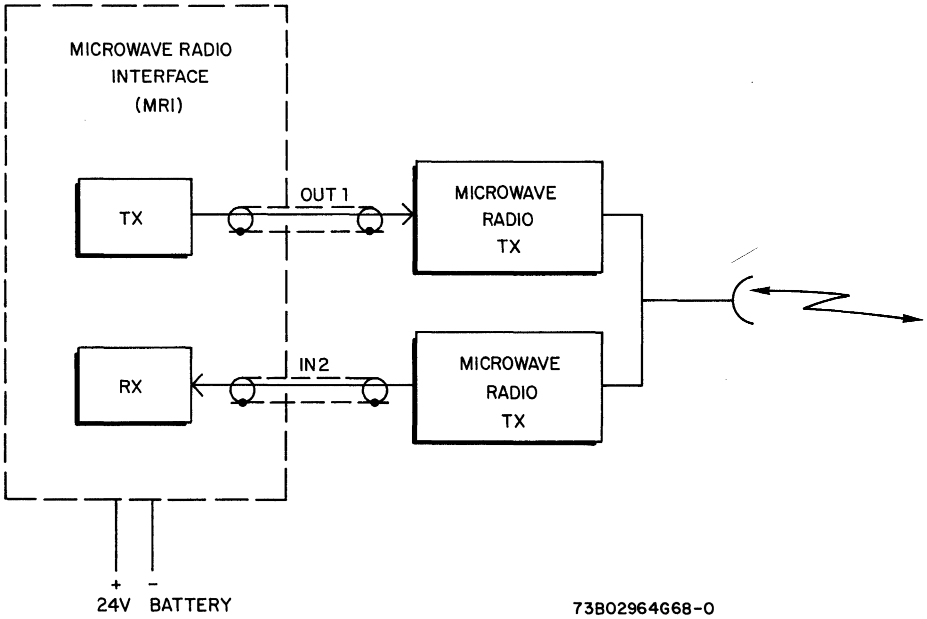

Figure 1. Interconnection Diagram

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In the receive mode, the signals received from the radio receiver baseband are amplified and a 4-8 kHz or an 8-12 kHz filter is selected, thus recovering the transmitted FSK tones. The tones are down-mixed and passed through a low-pass filter, providing the FSK tones (900/1500 Hz). These tones are sent out to the MRTU Basic Module through the MRTU bus (see Figure 2. MRI Block Diagram).

2. TRANSMITTER OPERATION

Transmission is possible only if the unit receives a PTT signal (-24 V) from the MRTU bus (pin 24 of the 26-pin connector). This signal lights the red LED and connects the IF filter to the output of mixer U8A through analog switch U8C (by providing a high level at pin 9 of U8C).

The PTT signal also enables U9C, U9D as well as U9A, U9B (if there is no jumper connected between pins 9 and 10 of the 14-pin user connector). Therefore, the transmitted signal at U6-8 is sent out to transformers T1 and T2 and then to the radio baseband. Resistors R51 and R52 minimize the loading when the unit is connected to the radio baseband without using a baseband combiner (for two-way repeater link only).

The PTT signal also disables analog switch U12C or U12D, thus disabling the receiver output.

2.1 MIXER STAGE

The mixer consists of analog switch U8A and operational amplifiers U1A, U1B which provide in-phase and anti-phase signals from the FSK two-tone signal (900/1500 Hz) received from the MRTU Basic Module at pin 26 of the 26-pin connector. Switch U8A is toggled by a local oscillator comprised of U4, U3, U5 and Q3.

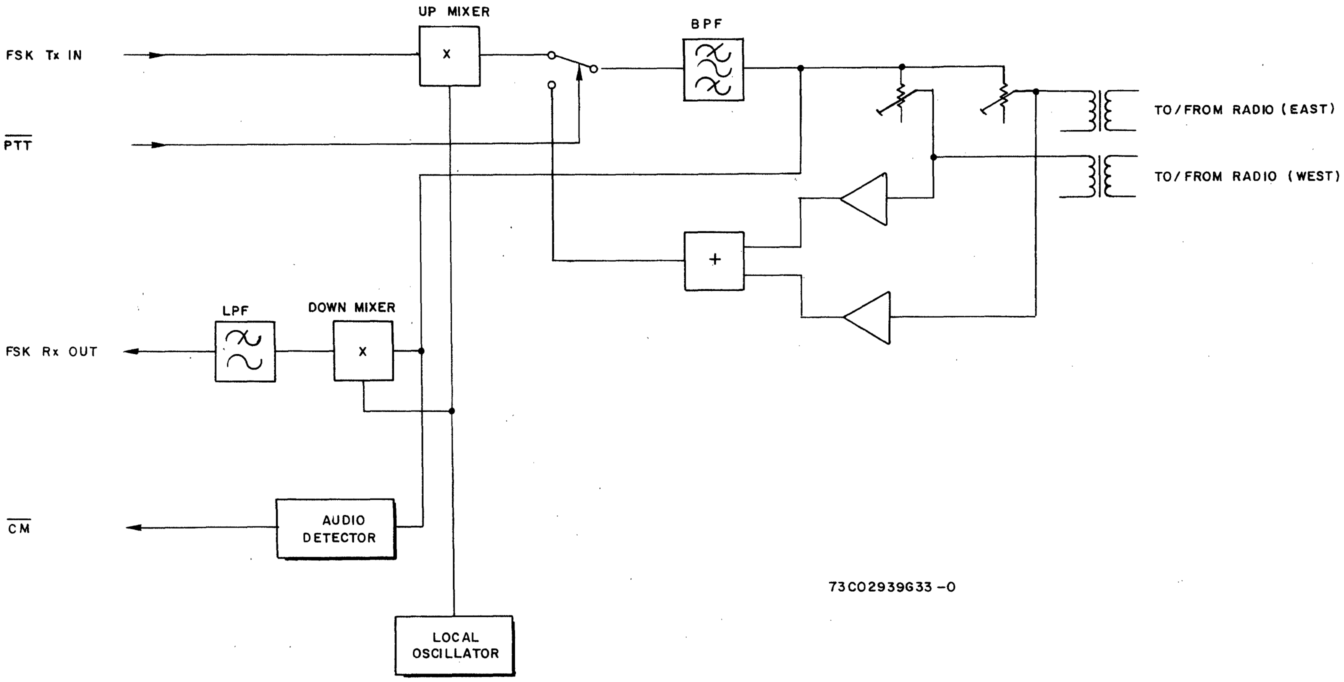


Figure 2. MRI Block Diagram

2.2 INTERMEDIATE FREQUENCY (IF) BANDPASS FILTER

U13, U14 and U6 comprise the bandpass filter. The filter is user-programmable through analog switches U12A, U12B and U7 (refer to Table 1. 4-8 kHz or 8-12 kHz).

Table 1. 4-8kHz or 8-12kHz

Operating Frequency Slot	4-8kHz	8-12kHz
Jumper at pins 10 and 11 of user connector	OUT	IN
U12A, U7A, U7B, U7C	OFF	ON
U12B, U7D	ON	OFF
Central IF frequency	5.6 kHz	9.6 kHz
Transmit/Receive tones on radio baseband	5.3 kHz & 5.9 kHz	9.3 kHz & 9.9 kHz
Local oscillator frequency	6.8 kHz	10.8 kHz

2.3 OUTPUT STAGE

The IF filter selects the lower sideband of the signal obtained after mixing, and attenuates the upper sideband by at least 50 dB. The IF filter output signal is sent to the isolation transformers. The baseband levels are independently adjustable by potentiometers R46 and R47 (user-adjustable) within a 30 dB range.

Analog switch U9 is ON only when there is a PTT signal. U9C, U9D are driven by the PTT signal. However, U9A, U9B are driven by PTT only when the jumper between pins 9 and 10 is in the OUT (default) position, which corresponds to a two-way link (see Figures 3. 2-Way Repeater Link, and 3a. 3-Way Repeater link and Table 2).

Table 2. Two Way/Three Way Operation

Radio Link Description	Two-Way	Three-Way
Jumper between pins 9 and 10	OUT	IN
Isolation transformer function (T1 and T2)	T1 and T2 Transmit and receive	T1 transmit T2 receives

3. RECEIVER OPERATION

Receive is possible only when there is no PTT signal (open collector on the MRTU bus). U9 is disabled, U8C connects the IF filter to the receive mode and U12C is ON, enabling the down-mixing and the output stage of the receiver.

3.1 INPUT STAGE

The baseband signals are coupled through isolation transformers T1 and T2 and are band-limited by low-pass filter R51, C20, R52 and C21 in order to remove the high-frequency spectrum of the baseband energy which may overload the receiver amplifiers.

The input amplifiers are comprised of U10A, U10D. The gains are user-adjustable through jumpers JU4 (pins 5, 6) and JU3 (pins 5, 8). See Table 3. Baseband Receive Level.

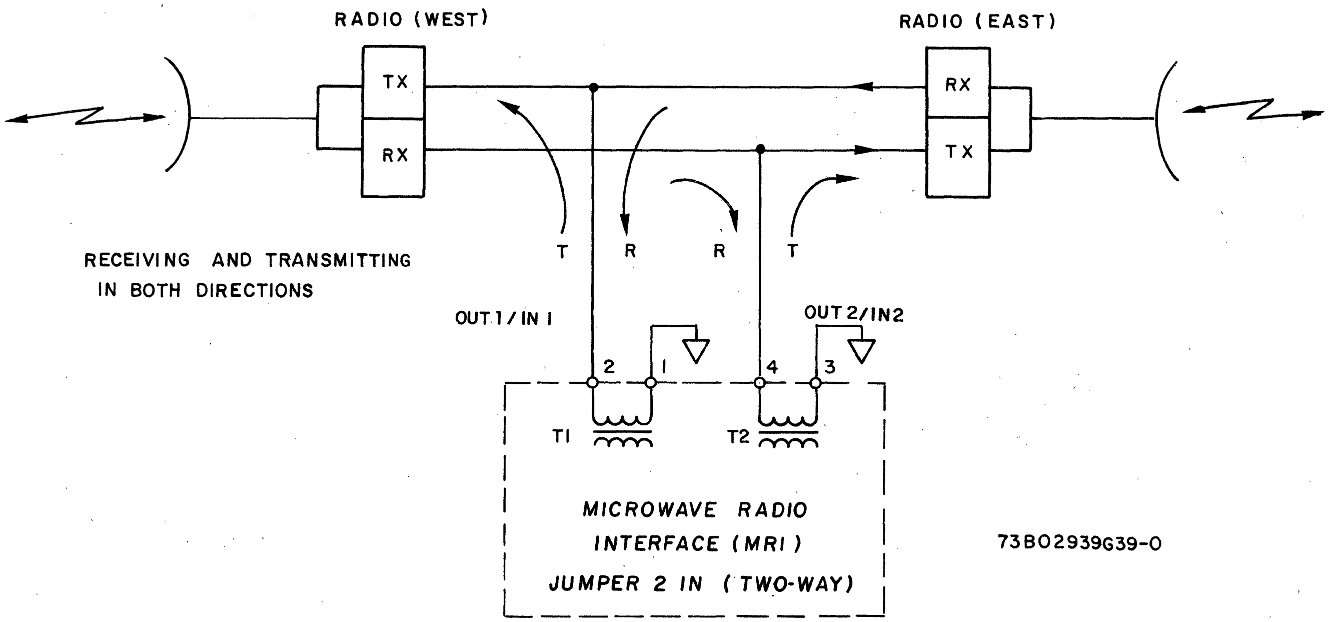

RADIO (WEST)
RADIO (EAST)
TX
RX
RX
TX
T
R
R
T
RECEIVING AND TRANSMITTING IN BOTH DIRECTIONS
OUT 1 / IN 1
OUT 2/IN2
2
1
4
3
T1
T2
MICROWAVE RADIO INTERFACE (MRI) JUMPER 2 IN (TWO-WAY)
73B02939G39-0

Figure 3. 2-Way Repeater Link

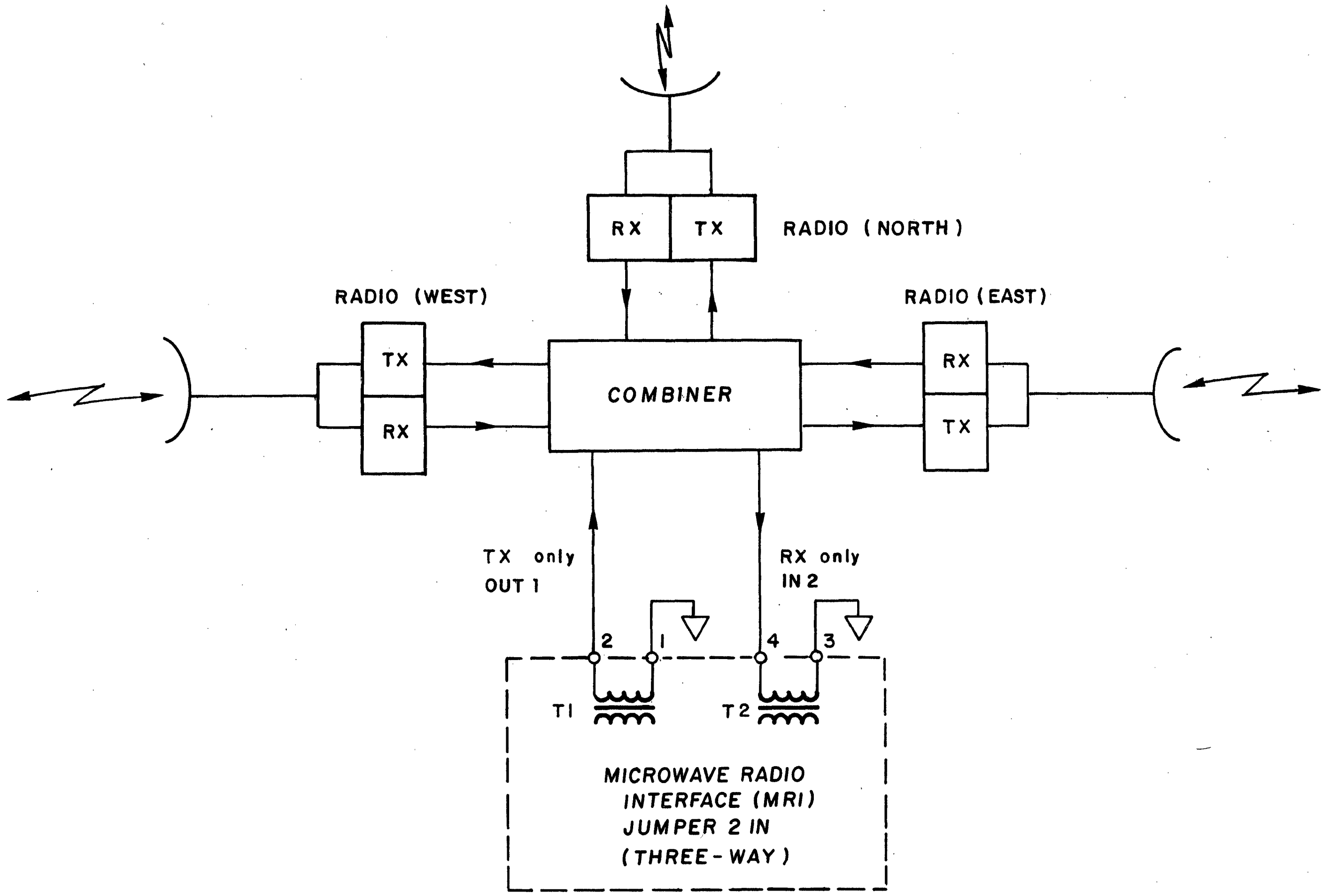


Figure 3a. 3-Way Repeater Link

73B02939G38-0

Table 3. Baseband Receive Level

Description	HI	LO
Input 1 baseband signal level	-13 dBm to -33 dBm	-33 dBm to -53 dBm
IN 1 Jumper 3 At pins 5-8 (of user connector)*	OUT	IN
Input 2 baseband signal level	-13 dBm to -33 dBm	-33 dBm to -53 dBm
IN 2 Jumper 4 At pins 5-6 (of user connector)*	OUT	IN
Gain	LO	HI

* Refer to Table 1.

The signals are then summed up by U10C and sent to the IF filter through analog switch U8C.

3.2 IF FILTER

The receiver uses the same filter as the transmitter for filtering out undesired baseband signals. The required signal is then passed to the down-mixer section through U12C which is now ON.

3.3 DOWN-MIXER STAGE

The mixer consists of amplifier U1C, U1D and analog switch U8B which is driven by the local oscillator. The output signal is then passed through the low-pass filter (U2D) which recovers the transmitted 900/1500 Hz tones and sends them out through the bus to the MRTU Basic Module.

3.4 CHANNEL MONITOR (CM)

The CM section, U2A, U2B, U2C sends out a signal (on the MRTU bus) whenever an FSK signal is received from the baseband.

The received signal is sensed at U1C-8 before down-mixing.

U2C is a peak-detector which charges capacitor C27 to the peak value of the tones received at U1C-8. U2A is a comparator whose output goes high whenever the voltage on C27 is higher than the reference voltage at U2A-2.

The voltage at U2A-1 charges capacitor C26 whose charging time-constant (R55 x C26) is much higher than the peak-detector time-constant (R61 x C27), in order to avoid response to noise spikes that might pass comparator U2A. Diode CR1 provides a rapid discharge path for capacitor C26.

The high output at U2B-7 causes green LED DS2 to light, signifying that the unit is receiving signals from the baseband and the channel is busy. At the same time, transistor Q2 is forced to conduct and its collector is connected to -24 V, thus, sending a low CM signal to the AMRTU bus.

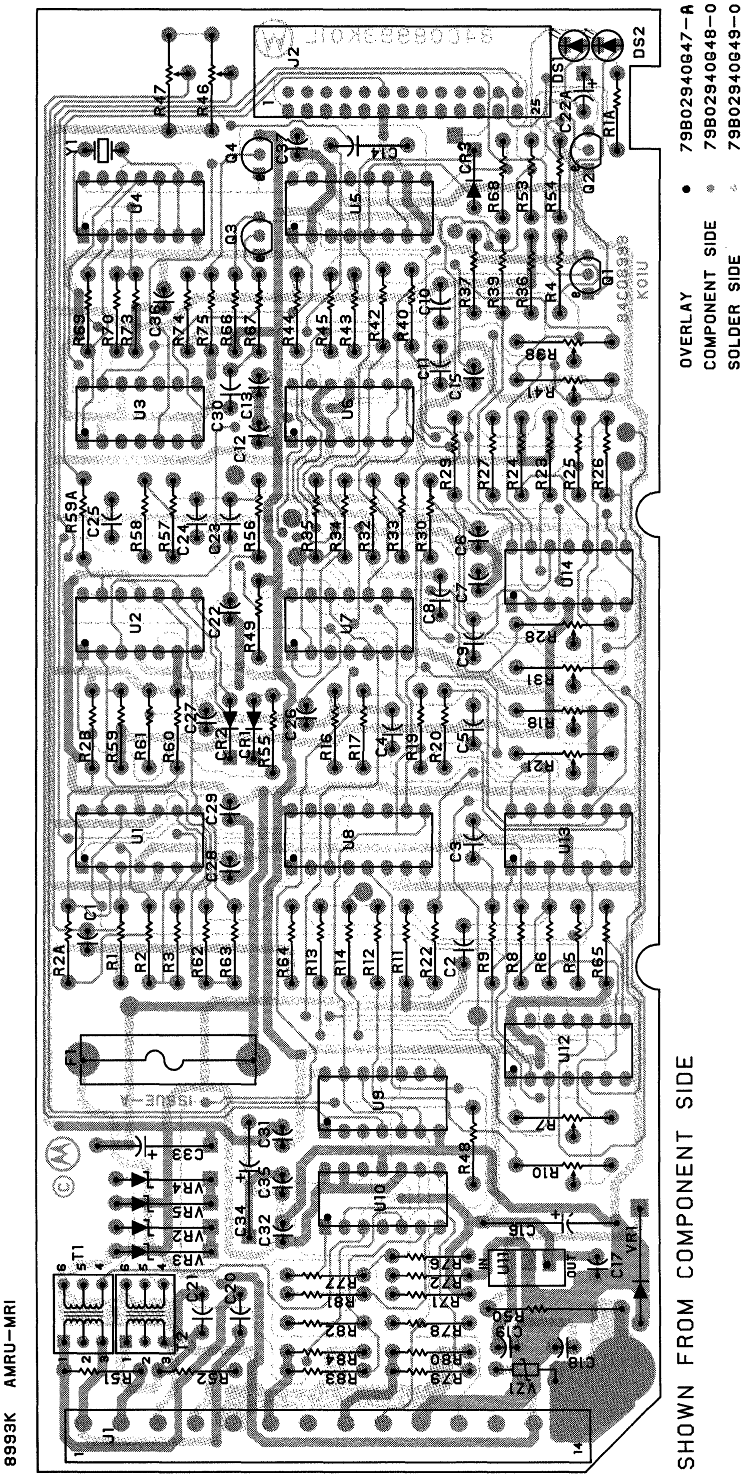
4. LOCAL OSCILLATOR

The local oscillator is comprised of a crystal-controlled oscillator (U4) followed by a programmable divider (U3, U5). The crystal frequency is 13.824 MHz (see Table 4. Oscillator Operation).

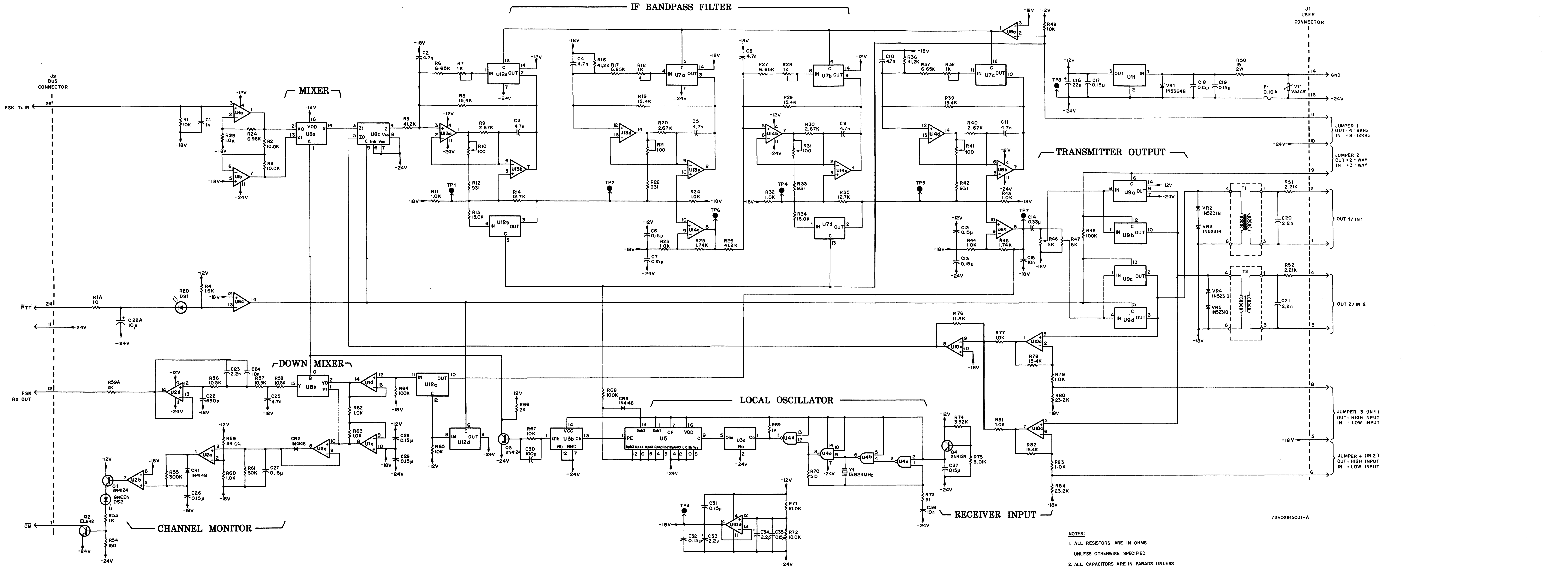
Table 4. Oscillator Operation

Operating frequency slot	4-8 KHz	8-12 KHz
Jumper 1 of user connector (pins 10-11)*	OUT	IN
U5 division ratio	127	80
Local oscillator frequency (Q3 collector)- kHz	6.8	10.8**

** The frequency of the oscillator (comprised of U4) is 13.824 MHz. The frequency is divided by 8 via U3A (which generates 1.728 MHz). U5 divides the frequency by 80 or 127, depending on the position of Jumper JU-1, thus generating one of two frequencies: 13.5 or 21.5 kHz. These frequencies are again divided by two, generating one of two 6.8 or 10.8 kHz frequencies.


SHOWN FROM COMPONENT SIDE
OVERLAY • 79B02940G47-A
COMPONENT SIDE 79B02940G48-0
SOLDER SIDE 79B02940G49-0
8993K AMRU-MRI
ISSUE-A
84C08993K01U

FLN7706A Microwave Radio Interface
Printed Circuit Board
July, 1988



NOTES:

1. ALL RESISTORS ARE IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN FARADS UNLESS OTHERWISE SPECIFIED.
3. U1, U2, U6, U10, U13, U14 = HA1-4741-2
   - U3 = MC74HC393J
   - U4 = 74HC00N
   - U5 = MC14569BCL
   - U7, U12 = MC14066BCL
   - U8 = MC14053BCL
   - U9 = MC14016BCL
   - U11 = MC7812CT
4. USED FOR SHARED RADIO OPTION ONLY

FLN7706A Microwave Radio Interface
Schematic Diagram
July, 1988

parts lists

FLN7706A Microwave Radio Interface Board PL-0418-A

Reference Symbol	Motorola Part No.	Description
		Capacitor fixed: uF ±1% unless otherwise stated
C1	21-82187B20	1 nF, Cer
C2 thru C5	21-02384C07	4.7 nF, NPO
C6, C7	21-84008H03	0.15
C8 thru C11	21-02384C07	4.7 nF, NPO
C12, C13	21-84008H03	0.15
C14	08-02083C10	0.33, 63 V MYLAR
C15	21-08029H02	10 nF, 10% CER
C16	23-84762H16	22
C17 thru C19	21-84008H03	0.15
C20, C21	21-02384C15	2.2 nF, 5% CER
C22	21-05453G05	680 pF, 5% NPO
C22A	23-84538G10	10, 20 V TANT
C23	21-02384C15	2.2 nF, 5% CER
C24	21-02384C06	10 nF, CER
C25	21-02384C07	4.7 nF, NPO
C26 thru C29	21-84008H03	0.15
C30	21-02384C26	100 pF; 10%; 50 V
C31, C32	21-84008H03	0.15
C33, C34	23-84762H04	2.2, 25 V TANT
C35	21-84008H03	0.15
C36	21-08029H02	10 nF, 10% CER
C37	21-84008H03	0.15
		Diode
CR1 thru CR3	48-11034A01	IN4148
		LED
DS1	48-80159E09	Red LED
DS2	48-80159E11	Green LED
		Fuse
F1	65-02069C30	0.16A
		Connector
J1	28-08508G04	14-pin connector
J2	28-08044H06	26-pin connector
		Transistor
Q1	48-02089C17	2N4124
Q2	48-00869787	NPN69787
Q3, Q4	48-02089C17	2N4124
		Resistor, fixed:±1%, 1/4 W unless otherwise stated
R1	06-11009C73	10k, ±5%
R1A	06-11009C01	10 ohm
R2, R3	06-10621C91	10.0k, T1
R2A	06-10621C76	6.98k T1
R2B	06-10621B94	1.0k, T1
R4	06-11009C54	1.6k, ±5%
R5	06-10621D51	41.2k, T1
R6	06-02478C38	6.65k, T9
R7	18-02467C08	potentiometer 1k
R8	06-02478C59	15.4k, T9
R9	06-02478C01	2.67k, T9
R10	18-02467C09	potentiometer 100 ohm
R11	06-02170C05	1.0k, T9
R12	06-02477C59	931 ohm, T9
R13	06-10621D09	15.0k, T1
R14	06-10621D02	12.7k, T1
R15	----	not used
R16	06-10621D51	41.2k, T1
R17	06-02478C38	6.65k, T9
R18	18-02467C08	potentiometer 1k
R19	06-02477C73	15.4k, T9
R20	06-02478C01	2.67k, T9
R21	18-02467C09	potentiometer 100 ohm
R22	06-02477C59	931 ohm, T9
R23	06-10621B94	1.0k, T1
R24	06-02170C05	1.0k, T9
R25	06-10621C18	1.74k, T1
R26	06-10621D51	41.2k, T1
R27	06-02478C38	6.65k, T9
R28	18-02467C08	potentiometer 1k
R29	06-02477C73	15.4k, T9
R30	06-02478C01	2.67k, T9
R31	18-02467C09	potentiometer 100 ohm
R32	06-02170C05	1.0k, T9
R33	06-02477C59	931 ohm, T9
R34	06-10621D09	15.0k, T1
R35	06-10621D02	12.7k, T1
R36	06-10621D51	41.2k, T1
R37	06-02478C38	6.65k, T9
R38	18-02467C08	potentiometer 1k
R39	06-02478C73	15.4k, T9
R40	06-02478C01	2.67k, T9
R41	18-02467C09	potentiometer 100 ohm
R42	06-02477C59	931 ohm, T9
R43	06-02170C05	1.0k, T9
R44	06-10621B94	1.0k, T1
R45	06-10621C18	1.74k
R46, R47	18-02467C03	potentiometer 5k
R48	06-11009C97	100k, ±5%
R49	06-11009C73	10k, ±5%
R50	17-82036G52	15 ohm, ±5%, 2W
R51	06-20621C28	2.21k
R52	06-10621C28	2.21k
R53	06-11009C49	1k, ±5%
R54	06-11009C29	150 ohm, ±5%
R55	06-11009D09	300k, ±5%
R56 thru R58	06-10621C93	10.5k
R59	06-10621D43	34.0k
R59A	06-11009C56	2k, ±5%
R60	06-10621C91	1.0k
R61	06-11009C84	30k, ±5%
R62, R63	06-10621B94	1.0k
R64	06-11009E25	100k, ±5%
R65	06-11009C73	10k, ±5%
R66	06-11009C56	2k, ±5%
R67	06-11009C73	10k, ±5%
R68	06-11009C97	100k, ±5%
R69	06-11009C49	1k, ±5%
R70	06-11009C42	510 ohm, ±5%
R71, R72	06-10621C91	10.0k
R73	06-11009C18	51 ohm, ±5%
R74	06-10621C45	3.32k
R75	06-10621C41	3.01k
R76	06-10621C98	11.8k
R77	06-10621B94	1.0k
R78	06-10621D10	15.4k
R79	06-10621B94	1.0k
R80	06-10621D27	23.2k
R81	06-10621C91	1.0k
R82	06-10621D10	15.4k
R83	06-10621B94	1.0k
R84	06-10621D27	23.2k
		Transformer
T1, T2	25-02059C06	MG21
		Integrated Circuit
U1, U2	51-02162C18	HA-4741-2
U3	51-08244G55	MC74HC393
U4	51-08244G04	MC74HC00N
U5	51-02073C40	MC14569BCL
U6	51-02162C18	HA-4741-2
U7	51-02073C59	MC14066BCL
U8	51-02073C64	MC14053BCL
U9	51-02073C09	MC14016BCL
U10	51-02162C18	HA-4741-2
U11	51-02190C14	MC7812CT
U12	51-02073C59	MC14066BCL
U13, U14	51-02162C18	HA-4741-2
		Crystal
Y1	48-02225K31	13.824 MHz
	14-82590G01	xtal insulator
		Zener Diode
VR1	48-02064C08	IN5364B
VR2 thru VR5	48-82256C15	IN5231B
		Varistor
VZ1	06-02597K03	V33ZA1
	Non Referenced Items	
	39-02092C01	contact male TP1-TP8
	09-02417H04	fuse holder
	84-08993K01	PC board
	29-02649H04	terminal block, 3 connectors
	29-05658K01	terminal lug; 2 used
	42-10217A02	band harness
	42-83123F01	retainer; 2 used

FLN7776A MRI Label Kit PL-0419-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	54-08124H08	MRI Label
	54-08635G19	MRI Identification Label

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ADJUSTMENTS AND MAINTENANCE

1. ADJUSTMENT AND MAINTENANCE INSTRUCTIONS FOR MRI

NOTE
The MRI module is adjusted at factory. The following adjustment instructions are provided for adjustments needed after user modifications have been performed.

WARNING
The AMRTU system operates from a positive ground supply. When connecting test equipment for maintenance purposes be sure to connect the ground probes to true ground only. For positive ground operation connect the ground probe to the (+) supply (not TP8 of the board). For negative ground operation connect the ground probe to the (-) supply (TP8 of the board).

1.1 FILTER ADJUSTMENTS AND TRANSMISSION TEST

Step 1. Connect 900 or 1500 Hz signal alternately, 120 mV rms (200 mV PTP) level via a 1 uF capacitor to pin 26 of connector J2.

Step 2. Connect an ac voltmeter to TP1 (+) and TP8 (-).

Step 3. Short between TP2 and TP3.

Step 4. Assure that the board operates on 4-8 kHz (J1, pins 10-11).

Step 5. Adjust potentiometer R10 for symmetric reading while entering 900/1500 Hz alternately.

Step 6. Set board operation to 8-12 kHz (J1, pins 10-11).

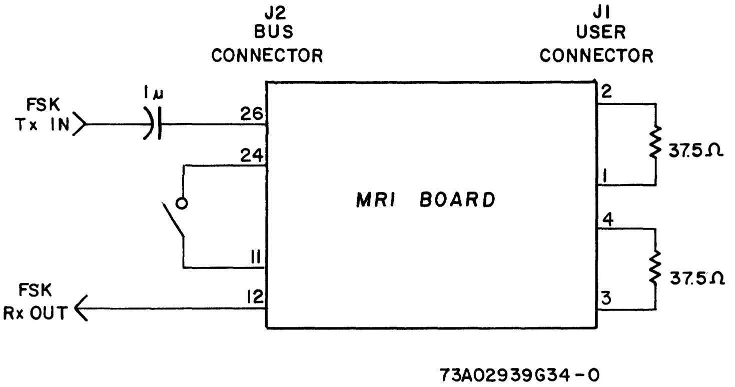

Figure 1. MRI Board Connections

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Step 7. Adjust potentiometer R7 for symmetric reading while entering 900/1500 Hz alternately.

Step 8. Disconnect shorting between TP2 and TP3.

Step 9. Connect the ac voltmeter to TP6.

Step 10. Return board operation to 4-8 kHz (J1, pins 10-11 OUT).

Step 11. Adjust potentiometer R21 to symmetric reading while entering 900/1500 Hz alternately.

Step 12. Set board operation to 8-12 kHz and set potentiometer R18 to symmetric reading while entering 900/1500 Hz alternately.

Step 13. Connect the ac voltmeter to TP4.

Step 14. Return board operation to 4-8 kHz (J1, pins 10-11 OUT).

Step 15. Short between TP3 and TP5.

Step 16. Adjust potentiometer R31 to symmetric reading while entering 900/1500 Hz alternately.

Step 17. Set board operation to 8-12 kHz.

Step 18. Adjust potentiometer R28 to symmetric reading as in Step 5.

Step 19. Disconnect shorting between TP3 and TP5.

Step 20. Connect the ac voltmeter to TP7.

Step 21. Return board operation to 4-8 kHz.

Step 22. Adjust potentiometer R41 to symmetric reading as in Step 5.

Step 23. Set board operation to 8-12 kHz.

Step 24. Adjust potentiometer R38 to symmetric reading as in Step 5.

Step 25. Disconnect the alternating voltmeter from the circuit.

Step 26. Assure that the two potentiometers R46 and R47 are set to maximum clockwise.

Step 27. Connect the ac voltmeter to a 37.5 ohm resistor inserted between pins 1 and 2 of connector J1 where pin 2 is (+) and pin 1 (-). Set reading for more than -26 dBm.

Step 28. Repeat Step 27 with board operation set for 4-8 kHz.

Step 29. Connect the ac voltmeter to a 37.5 ohm resistor inserted between pins 3 and 4 of connnector J1 where pin 4 is (+) and pin 3 (-). Set reading for more than -26 dBm.

Step 30. Repeat Step 27 with board operation set for 8-12 kHz.

1.2 RECEIVER TEST

Step 1. Connect 5300 Hz or 5900 Hz signal alternately to operate at 4-8 kHz range.

Step 2. Connect 9300 Hz or 9900 Hz signal alternately to operate at 8-12 kHz range.

Step 3. Set the frequency generator to -13 dBm output level on a 37.5 ohm resistor at channel input 1 or 2.

- Channel 1 (+) is connected to pin 2 of connector J1 and (-) to pin 1 of connector J1.

- Channel 2 (+) is connected to pin 4 of connector J1 and (-) to pin 3 of connector J1.

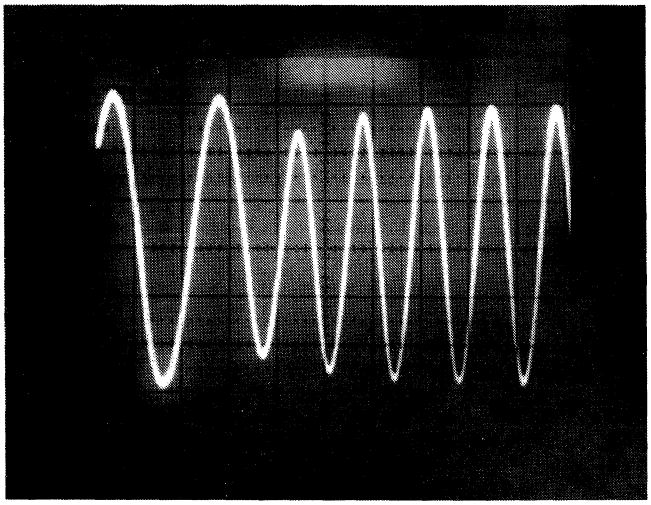
Step 4. Connect ac voltmeter adjusted for 75 ohm to pin 12 connector J2 and ensure reading of +10 - +13 dBm.

Step 5. Repeat test in both channels and both inputs.

Signal: FSK TX

Measuring Point: J2-26

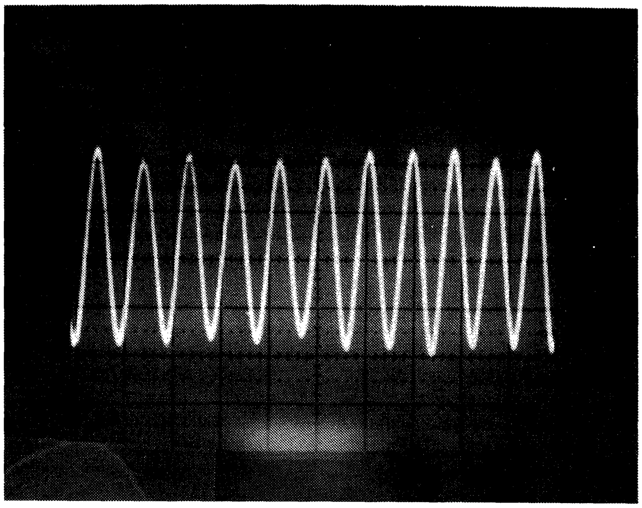
Scale: 0.5 msec/CM



69A02944G85-0

Measuring Point: TP2

Scale: 0.2 V/CM
0.2 msec/CM



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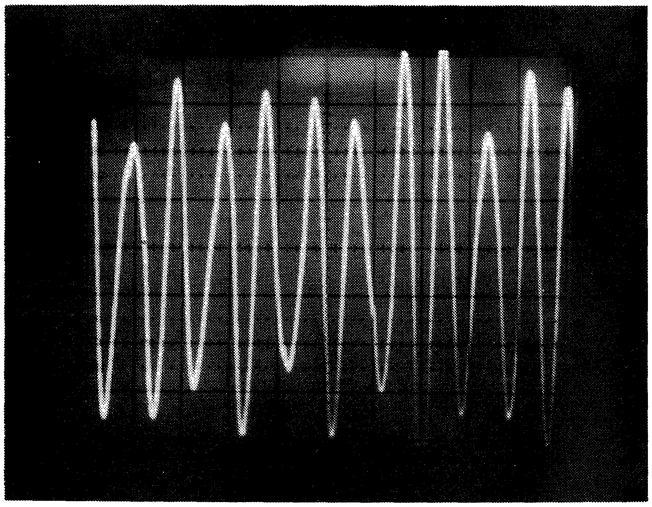
Measuring point: TP1

Scale: 0.2 V/CM
0.2 msec/CM



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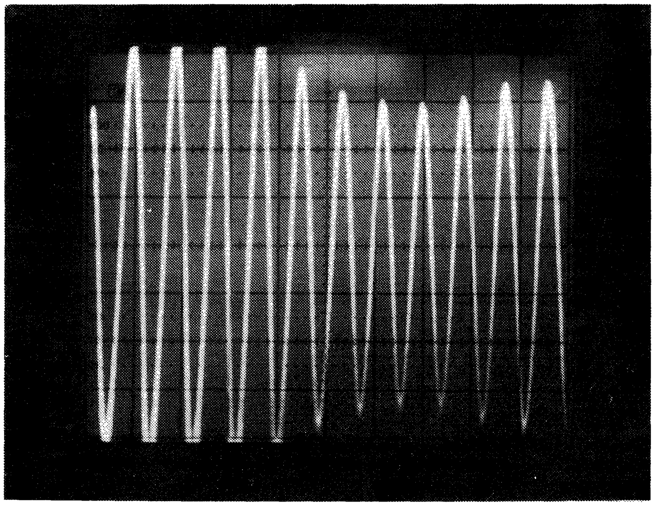
Measuring point: TP4

Scale: 0.2 V/CM
0.2 msec/CM



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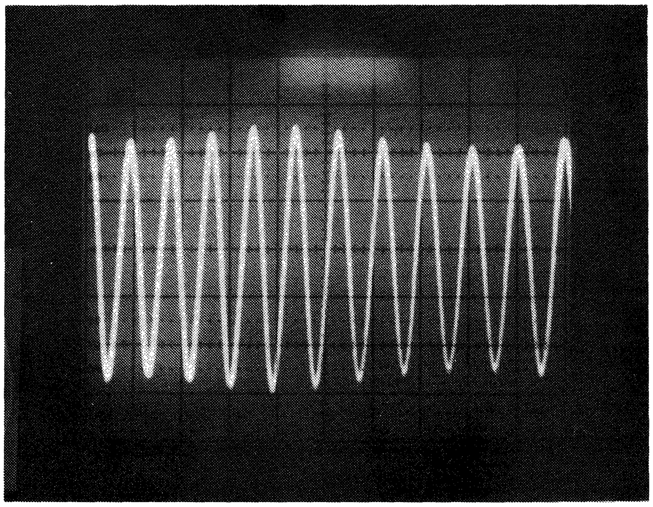
Measuring Point: TP5

Scale: 0.2 V/CM
0.2 msec/CM



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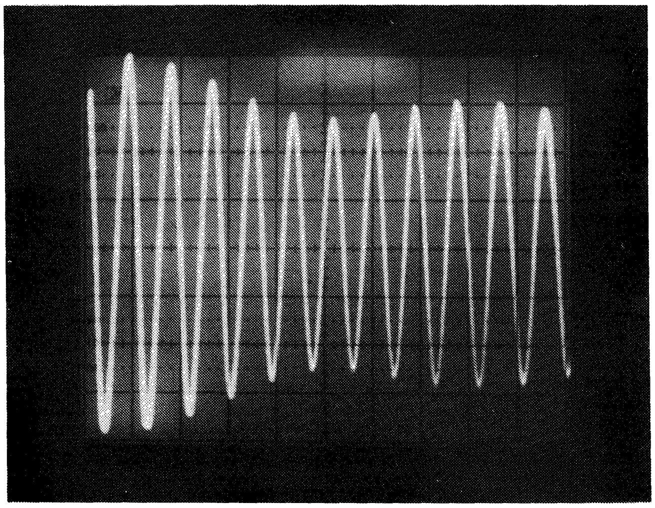
Measuring point: TP7

Scale: 0.5 V/CM
0.2 msec/CM



69A02944G90-0

MISCELLANEOUS PARTS LISTS

parts list

FLN7790A Panel Mounting Kit PL-0420-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Items	
	03-00119947	screw 6-20; 2 used
	03-00121057	screw 6-32X3/8
	03-02432C28	screw 4-40; 2 used
	04-00007698	washer lock 3/8; 2 used
	04-02439C08	washer #6; 2 used
	05-10277A17	grommet
	07-08495L01	module mounting tray
	09-00855268	connector; 2 used
	09-82083C01	fuse holder
	29-02231C16	lug
	29-02649H04	terminal block 3 conn.
	29-05658K01	terminal lug; 2 used
	30-08564C02	coloured wires; 9 used
	42-10217A02	band harness; 5 used
	48-02082C17	diode 1N1199A
	64-08293L01	back panel MRI
	65-00042092	fuse 2A, 250V

INTRAC 2000
Modular Remote Terminal Unit
Microwave Radio Interface

68P02963G50-0

MOTOROLA INC
Communications
Sector

-48 V POWER SUPPLY

Model FPN1611A

1. -48 V OPERATION FOR AMRTU MODEL (OPTION V034AA)

For the above-mentioned option:

add: FPN1611A -48 V Power Supply
FRN1734A MRI for -48 V
omit: FLN1477A MRI

1.1 GENERAL DESCRIPTION

The -48 V option enables the system to operate from a -48 V dc supply.

When using the -48 V option with the AMRTU system, it should be noted that the -48 V to -24V power supply occupies the space of one module, thus the maximum number of modules which can be located in the chassis is limited to 9.

1.2 SPECIFICATIONS

Input Voltage	-22 to -58 V
Input Power	18 W maximum
Output Voltage	-16 to -24 V
Output Current	0.3 A maximum
Input Protection	overvoltage reverse polarity IEEE 478
Output Protection	short circuit via fuse

1.3 INSTALLATION

Connect the input power (-48 V and GND) to the appropriate connector (refer to the figure on page 2, -48 V User Connection, for details).

For all AMRTU settings and adjustments, refer to 68P02963G50 Microwave Radio Interface Instruction Manual, Installation section.

2. FLN4662A -48 V to -24 V PC BOARD

2.1 THEORY OF OPERATION

The voltage conversion is based on a linear voltage regulator (LM237T).

R1 controls the output voltage. VR1 protects against overvoltage or opposite input connection. R3 determines the minimum operating current. CR1 protects U1 against an input short circuit, and CR2 protects U1 against an output short circuit. R4 and Q2 (on external heatsink) serve as current boost.

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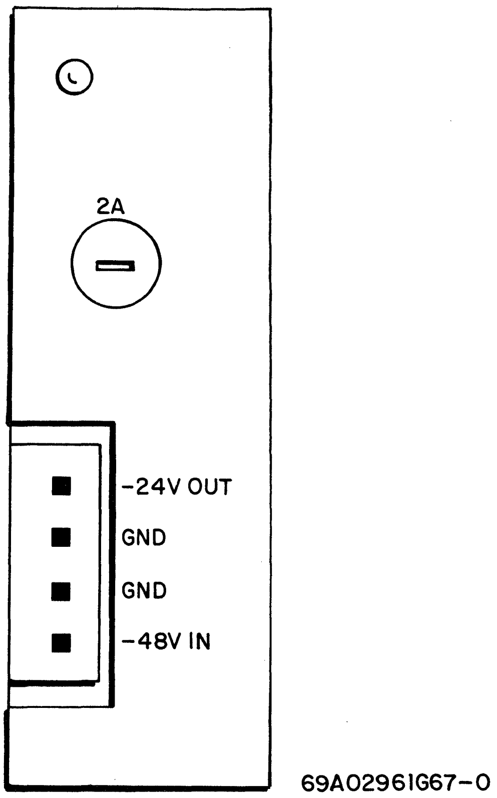

Figure 1. -48 V User Connection

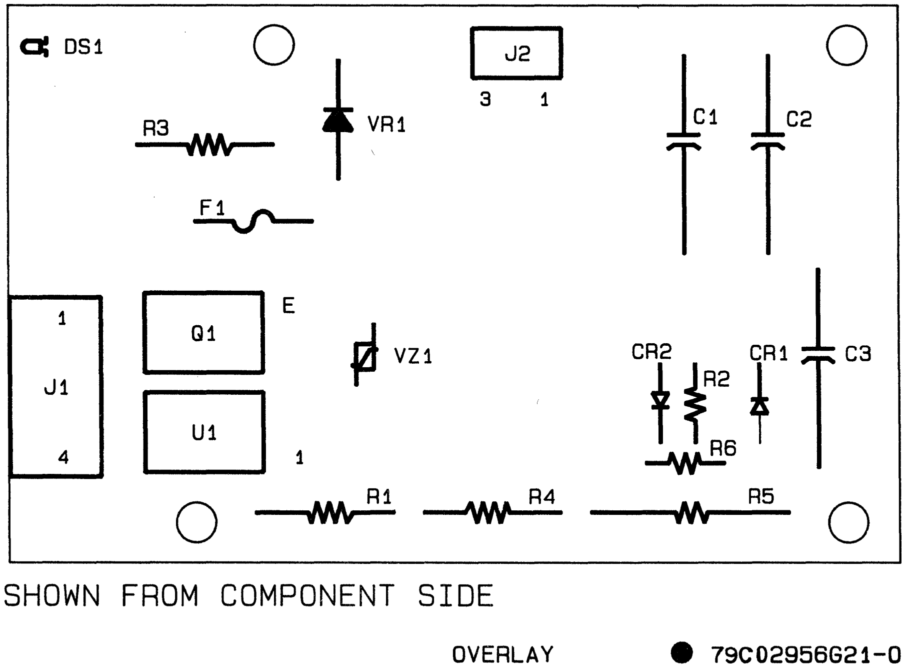

Figure 2. Printed Circuit Board Detail

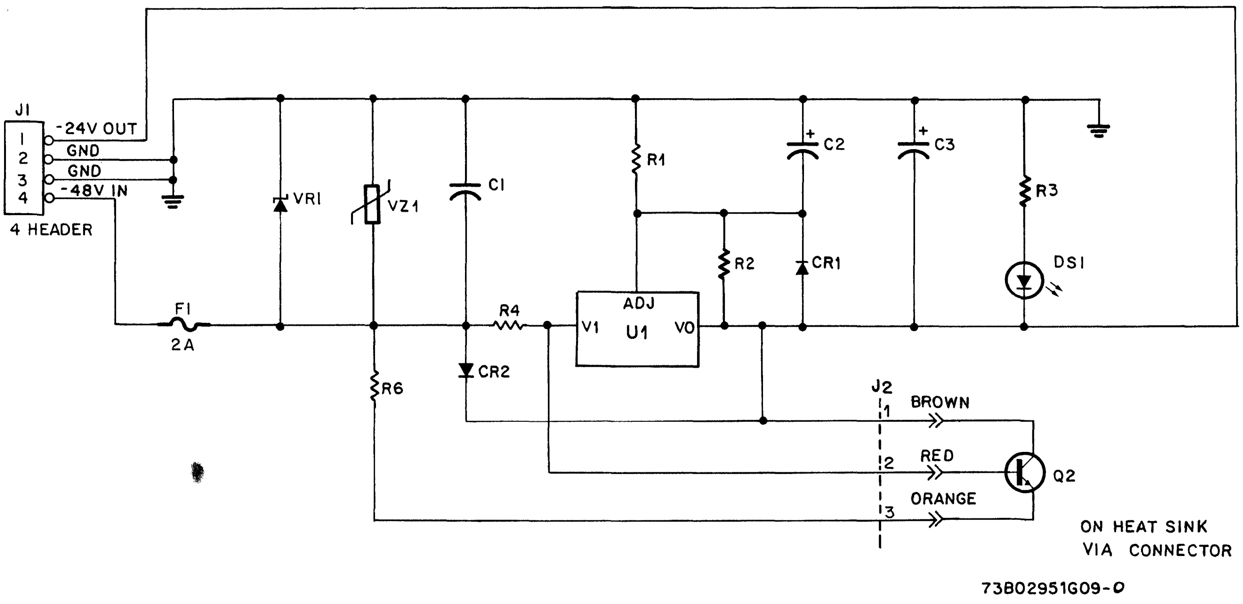

Figure 3. Schematic Diagram

parts lists

FLN4662A -48 V to -24 V Board PL-0687-O

Reference Symbol	Motorola Part No.	Description
		Capacitor
C1 thru C3	23-02234C17	22 uF
		Diode
CR1, CR2	48-82466H13	66H13; 200 V
		LED
DS1	48-88245C06	green
	43-02407H01	socket for LED
		Fuse
F1	65-00042092	2 A 250 V
	09-02417H05	fuse holder
	38-02387L01	cap for fuse holder
		Connector
J1	31-02151C18	3 cont
J2	28-08036H02	3-pin connector
		Resistor
R1	17-02201C28	1.8k
R2	06-11609C27	120 ohm
R3	17-02201C28	1.8k
R4	17-02201C33	680 ohm
R5	-----	not used
R6	06-11009D23	0 ohm
		Transistor (see note)
Q1	----	Not used
Q2		Part of FLN4663A
		Integrated Circuit (see note)
U1	51-02190C23	LM337T voltage regulator
		Zener Diode
VR1	48-02064C29	1N5373B
		Varistor
VZ1	06-02597K04	varistor 100
	Non Referenced Item	
	84-08319L01	printed circuit board

Note: For optimum performance, order diodes, LEDs, transistors and integrated circuits by their Motorola part number.

FLN4663A -48 V to -24 V Housing PL-0688-O

Reference Symbol	Motorola Part No.	Description
	Non Referenced Item	
	03-02432C23	mach screw 4-40x1/6; 2 used
	03-02432C45	mach screw 6-32x3/8; 4 used
	03-02433C45	mach screw 6-32x3/8; 4 used
	03-02457C02	metal screw; 2 used
	04-02439C03	lock washer 145x285x.019; 4 used
	04-02439C08	lock washer .145x.285x.019; 4 used
	04-02440C02	flat washer .125x9/32x.025; 2 used
	04-02440C03	flat washer .140x5/16x.032; 4 used
	04-02440C08	flat washer .140x5/16x.032; 4 used
	07-08753L01	bracket
	14-02453C07	mica insulator (for Q?)
	15-02212K01	transistor cover
	26-08868L01	heatsink
	37-00080778	rubber grom .252 blk.
	43-02454C03	bush for TO-66; 4 used
	48-00869639	transistor M9639 (Q2)